RESEARCH AND STANDARDS
GO HAND IN HAND

Under the watchful eyes of a Goodyear laboratory technician, the Instron tests a new synthetic rubber for tensile strength and elongation at ambient temperature.

How GOODYEAR uses the INSTRON TESTER

The Goodyear Tire & Rubber Company, Akron, Ohio, takes full advantage of Instron's unique versatility in testing the performance of numerous materials and products.

If you were to walk into the Research Division Laboratories of the company tomorrow morning, you might find Instrons testing a synthetic rubber for tensile strength . . . measuring the elongation and strength of tire cord . . . testing "Airfoam" recovery after compression . . . or measuring tensile strength, elongation and adhesion of various rubber and plastic materials at automatically controlled temperatures ranging from −250° F to 650° F.

Whatever your field of materials testing, Instron's capacity to do more . . . and do it more accurately . . . can be put to work for you. The facts are waiting. Why not write today?

The Instron comes in various models and sizes, to suit the widest applications — for tests under all sorts of environmental conditions — with load ranges from 2 grams full scale to 10,000 lbs. ILLUSTRATED: TABLE MODEL.

INSTRON
ENGINEERING CORPORATION
2500 Washington Street *Canton, Massachusetts*

INSTRON

FOR FURTHER INFORMATION CIRCLE 797 ON READER SERVICE CARD

Reg. U. S. Pat. Off.

Raymond E. Hess
Editor
Virginia Burkhart
Assistant Editor
Albert L. Batik
Advertising

George A. Wilson
Production Editor, ASTM Publications

OFFICERS

Board of Directors

President
R. T. Kropf

Vice-Presidents
K. B. Woods — F. L. LaQue

Directors

Term ending 1958
R. C. Alden
A. A. Bates
.....
E. F. Lundeen
J. C. Moore

Term ending 1959
M. N. Clair
H. C. Cross
G. H. Harnden
R. R. Litehiser
C. R. Stock

Term ending 1960
C. L. Clark
A. E. Juve
J. H. Koenig
R. E. Peterson
R. W. Seniff

Past-Presidents
N. L. Mochel — C. H. Fellows
R. A. Schatzel

Executive Secretary
R. J. Painter

COMMITTEE ON PAPERS AND PUBLICATIONS

This committee has authority in all matters affecting the acceptance, rejection, editing and publication of papers, committee reports, and discussions. The committee also acts in an advisory capacity to the Board of Directors on publication matters in general.

R. E. Hess, *Chairman*
Robert Burns — A. C. Smith, Jr.
C. A. Carpenter — C. R. Sutton
I. J. Dolan — L. W. Wood
F. M. Howell — L. L. Wyman
R. J. Wirshing

Corresponding Members from Pacific Coast District
F. J. Converse — R. E. Davis

ASTM BULLETIN

FEBRUARY 1958

Number 228

Telephone: Rittenhouse 6-5315 — Cable Address: Testing, Philadelphia

Page

Standardization from an Air Line Viewpoint—R. D. Kelly 25
Proposed Method for Measurement of Extreme Pressure Properties of Lubricants 28
Autographic Stress-Strain Recorders—R. B. Bouche and D. R. Tate 33
A Stress Computer for the SR-4 Testing Machine—R. D. Behr and J. A. Gusack 43
A True Stress–True Strain Computer—T. S. DeSisto and D. E. Driscoll 46
A High-Speed Tension Testing Machine—S. Strella, H. Sigler, M. Chmura, and B. Holman 50
A Progress Report—Measurement of Surface Moisture—P. J. Sereda 53
Preparation of Samples for the Geiger Counter Diffractometer—L. E. Copeland and R. H. Bragg 56
Application of Ion-Exchange Chromatography to the Analysis of Commercial Triphosphate—W. G. Spangler, D. E. Howes, and J. A. Kish 61
Exploratory Fire Tests with Small-Scale Specimens—H. D. Foster 66
Discussion of Paper on Temperature of Bituminous Roof Surfaces 67

IN THE SOCIETY

Biggest Annual Meeting Shaping Up 5
New ASTM Publications 9
Actions on Standards 10
Membership—ASTM Lifeblood 11
Schedule of ASTM Meetings 11
ASTM Finances in 1957 12
ACR Notes 13
Technical Committee Notes 14
NEW SBR Numbers 15
ASTM-GSA Contract Renewed 15
Cement Reference Laboratory Work Extended 16
ASTM Participates in Nuclear Congress 16
Committee A-5 Celebrates 50th Anniversary 17
Personals 76
New Members 84
Deaths 97

GENERAL NEWS NOTES

Other Societies' Events 15
OTS Research Reports 16
Industrial Progress in Nuclear Field in 1957 21
Unlimited Horizons for Radioisotopes 27
The Bookshelf 71
Laboratory Supplies and Testing Equipment 92
ASA Approvals of ASTM Standards 98
Government Standards Index Changes 102

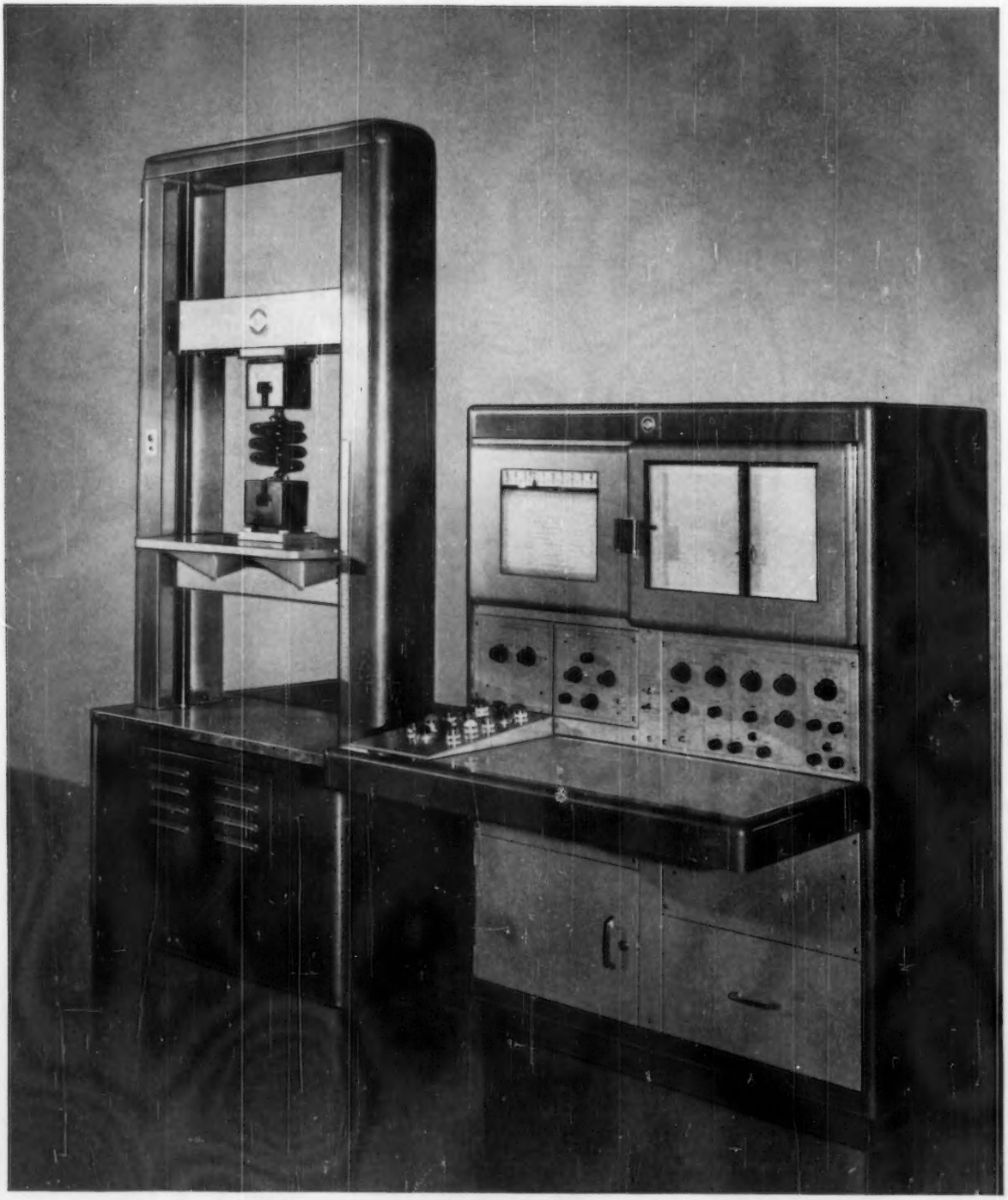
ASTM Bulletin is indexed regularly by Engineering Index Inc.
ASTM Bulletin is available on microfilm from University Microfilms, Ann Arbor, Mich.

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

ASTM Bulletin, February 1958. Published eight times a year, January, February, April, May, July, September, October, and December, by the American Society for Testing Materials. Publication Office—20th and Northampton Sts., Easton, Pa. Editorial and advertising offices at the headquarters of the Society, 1916 Race St., Philadelphia 3, Pa. Subscriptions, United States and possessions, one year, $2.75, two years, $4.75, three years, $6.50; Canada, one year, $3.25; two years, $5.75; three years, $8.00. Other countries, one year, $3.75; two years, $6.75; three years, $9.50. Single Copies—50 cents. Number 228. Second-class mail privileges authorized at Easton, Pa.
© Copyrighted 1958, by the American Society for Testing Materials.

NEWS FROM B-L-H

VERSATILE SERVOMATIC TESTING MACHINE



MARK G

FEATURES FIXED TEST CENTER

Lightweight, rigid construction—dual platen motion—single space test area —fixed test center for permanent positioning of accessory equipment

The new design and operating principles of the Mark G Servomatic Tester offer versatility and convenience for production and research testing. A wider, more varied range of tests is possible.

The platens of the Mark G, powered by counter-rotating, preloaded ball-bearing screws, move simultaneously in opposite directions. This keeps the test center in fixed position 56½ in. above the floor. Any accessory equipment, such as furnaces, will remain stationary during a test. Strains are electronically measured with high accuracy by built-in SR-4® transducers employing bonded wire strain gages.

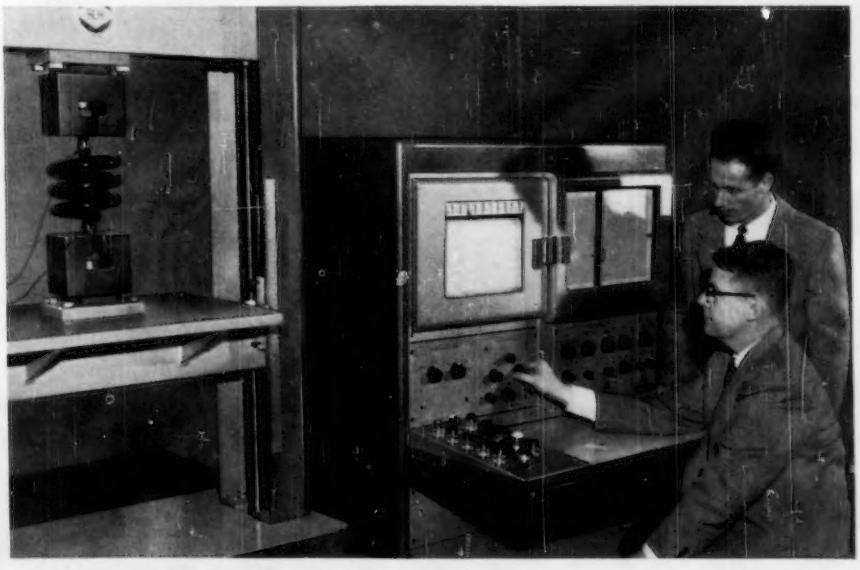
The space available for specimens is from 0 to 48 in. and a servocontrolled hydraulic motor moves the platens at speeds up to 20 in. per min. The system self-locks for safety when not running. Electric clutches allow remote speed selection and provide overload protection.

Maximum frame rigidity results from the reduced area occupied by the test load. This is limited to a rectangle formed by the platens and the length of interconnecting screws (determined by the size of the specimen).

The Mark G also offers automatic loading or straining (with SR-4 extensometer), automatic load holding, strain and straining head position holding, and automatic cycling for load or strain in frequencies of from 6/10 to 60 cpm. Two conveniently located built-in sockets permit plug-in of SR-4 strain gages and of microformers or extensometer.

For the best in testing, see B-L-H first. Choose from industry's most complete line of testing equipment—tension, compression, creep, fatigue, impact or torsion. Ask your B-L-H representative about the Mark G Servomatic Tester—or write Dept. 4B for Bulletin #4218.

◀ New Mark G Servomatic Tester and console for tension-compression testing can be ordered in capacities up to 300,000 lb.



Console for Mark G includes instrument controls and two plotters. XY plotter (right) computes crosshead motion vs. load or specimen strain (with use of microformer or SR-4® extensometer) vs. load; a dual pen strip chart recorder (left) graphs load or strain vs. time, works simultaneously with XY plotter. ▶

BALDWIN · LIMA · HAMILTON

Electronics & Instrumentation Division

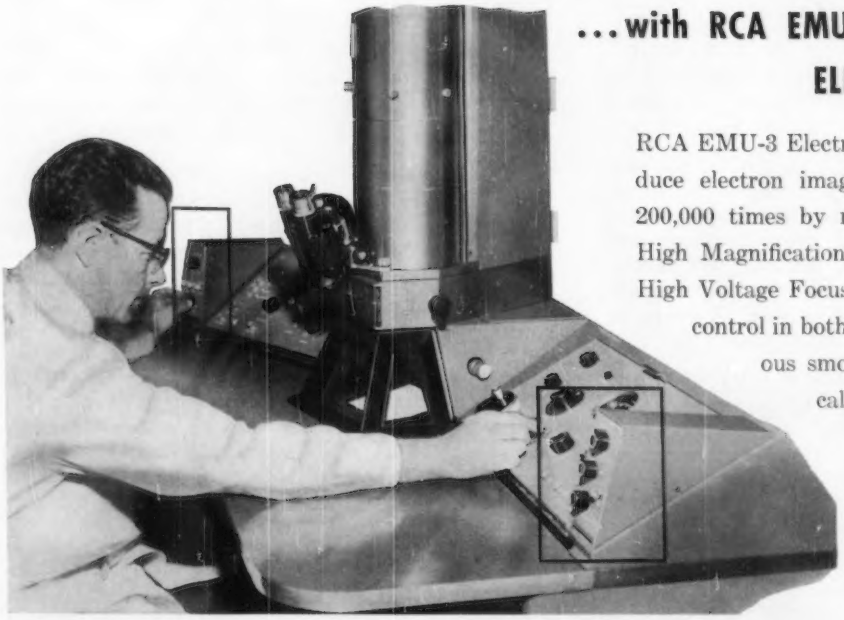
Waltham, Mass.

Testing machines • SR-4® strain gages • Transducers

©Copyright 1958, E & I Div., B-L-H Corp.

FOR FURTHER INFORMATION CIRCLE 798 ON READER SERVICE CARD

NOW...Direct Magnifications up to 200,000X!



...with RCA EMU-3 ELECTRON MICROSCOPE

RCA EMU-3 Electron Microscopes can now produce electron images magnified *directly* up to 200,000 times by means of a newly developed High Magnification Kit. RCA is also offering a High Voltage Focusing Kit which provides focus control in both calibrated steps and continuous smooth linear change. It practically eliminates image movement while adjustments are being made. As an additional feature, these kits provide convenient lens normalizing buttons for microscopes not so equipped.

FEATURES OF RCA HIGH MAGNIFICATION KITS:

1. Reduce need for extreme photographic enlargement, thus minimizing the effect of grain.
2. Reveal new fine structures.
3. Simplify lens compensation.
4. Increase output of high quality micrographs.

These new Accessory Kits are available as optional equipment with all EMU-3 Electron Microscopes now being shipped. They can also be supplied for all EMU-3 Electron Microscopes now in use. Both units blend with present instrument panel styling and are easily mounted in position.

Hundreds of RCA Electron Microscopes have been responsible for brilliant accomplishments in many fields. They have opened many new avenues of exploration in chemistry, metallurgy, medicine, bacteriology and biology. The technique of operation is easily acquired by any competent technician.

For additional information on RCA's new Accessory Kits or literature on the RCA Electron Microscope for specific applications, write to RCA, Dept. C-335, Building 15-1, Camden, N.J.

RCA

Tmk(s) ®

RADIO CORPORATION of AMERICA

CAMDEN, N. J.

FOR FURTHER INFORMATION CIRCLE 799 ON READER SERVICE CARD

ASTM's largest technical program shaping up

61st Annual Meeting

BOSTON will be the Hub of the materials research and technology world the week of June 22 when an anticipated 4000 ASTM members, committee members, and guests converge on the Hotels Statler and Sheraton Plaza for ASTM's 61st Annual Meeting.

Complete details of this big meeting will appear with the Provisional Program in the April issue of the ASTM BULLETIN. Outlined on these pages are some of the highlights of the technical, social, and special events of the week, including titles and authors of the papers in the symposia.

In addition to the committee-sponsored symposia and sessions listed below, there will be sessions on Fatigue, High Temperature, Steel, Cement, and Non-Ferrous Metals.

Symposium on Effect of Water on Bituminous Paving Mixtures

Sponsored by Committee D-4 on Road and Paving Materials

Field Observations of the Behavior of Bituminous Pavements as Influenced by Moisture—*Ward K. Parr, University of Michigan*

Relationship of Aggregate Characteristics to the Effect of Water on Bituminous Paving Mixtures—*J. M. Rice, National Crushed Stone Assn.*

Laboratory and Field Tests on Asphalt Paving Mixtures—*E. W. Klinger and J. C. Roediger, Esso Research and Engineering Co.*

Effect of Additives—*Paul Critz, Bureau of Public Roads*

Methods of Testing for Water Resistance of Bituminous Paving Mixtures—*W. H. Goetz, Purdue University*

Symposium on Paper and Paper Products—New Developments with Accompanying Requirements for New Testing Methods

Sponsored by Committee D-6 on Paper Products

Some Historical Developments in Paper Testing—*W. R. Willets and F. R. Marchetti, Titanium Pigment Corp.*

Testing of Synthetic Fiber Papers—*F. H. Koontz and J. K. Owens, E. I. du Pont de Nemours & Co., Inc.*

Technology of Non-Woven Structures: Paper and Textile Processes and End Uses—*J. T. Taylor and P. J. McLaughlan, Rohm & Haas Co.*

New Developments in the Internal Bonding of Paper—*K. W. Britt, Scott Paper Co.*

The Role of Paper in Printed Circuitry—*N. A. Skow, Synthane Corp.*

Polyethylene Extrusion Coated Papers, an Appraisal of Testing Methods—*K. Thompson, Lowe Paper Co.*

New Approaches in Packaging Material Testing for the Food Industry—*P. K. Wolper, Riegel Paper Corp.*

Knit Paper—Its Uses As a Utilitarian Textile—*R. H. Marks, Enterprise, Inc.*

Symposium on Radioactivity in Industrial Water and Industrial Waste Water

Sponsored by Committee D-19 on Industrial Water

Radioactivity and Purity Control of APPR Primary Water—*A. Louis Medin, Alco Products, Inc.*

Radioactive Waste Processing and Control at the Shippingport Atomic Power Station—*S. F. Whirl and J. A. Tash, Duquesne Light Co.*

Test Methods for Radiation Hazards in Industrial Water—*C. J. Munter, Hagan Chemicals and Controls, Inc.*

Analysis for Radionuclides in Aqueous Wastes from an "Atomic" Plant—*B. Kahn, Massachusetts Institute of Technology; D. W. Moeller, U. S. Public Health Service; T. H. Handley, and S. A. Reynolds, Oak Ridge National Laboratory*

The Analysis of Environmental Samples for Radionuclides—*D. L. Reid, General Electric Co.*

Summation—*J. M. Seamon, National Aluminate Corp.*

Symposium on Particle Size Measurement

Sponsored by Committee E-1 on Methods of Testing

Centrifuge Sedimentation Size Analysis of Membrane Filter Collected Samples of Airborne Dusts—*K. T. Whitby and A. B. Ahren, University of Minnesota*

The Mechanics of Fine Sieving—*K. T. Whitby, University of Minnesota*

Use and Limitations of the Blaine Fineness Tester—*S. S. Ober and K. J. Frederick, Abbott Laboratories*

Symposia on

- Effect of Water on Bituminous Mixtures
- Paper
- Radioactivity in Water
- Particle Size Measurement
- Solvent Extraction
- Durability in Structures
- Fatigue
- Soil Testing
- Radiation Effects
- Bulk Sampling
- Materials Research Frontiers

Sessions on

- Fatigue
- High Temperature
- Steel
- Cement
- Non-Ferrous Metals
- Concrete
- Road and Paving Materials
- Textiles
- Soils

Boston

June 22—27

A Photoelectric Sedimentation Method for Particle Size Determination in the Sub-Sieve Range—*H. R. Harner and J. R. Musgrave, The Eagle-Picher Co.*

An Accurate Dry Sieving Analysis through Smallest Aperture Sieves is Now Practicable—*Alan R. Lukens, Lukens Laboratories*

A Review of Sieve Standardization—*L. Judson, National Bureau of Standards*

Sedimentation Procedure for Determining Particle Size Distributions—*A. E. Jacobson and W. F. Sullivan, National Lead Co.*

A Liquid Sedimentation Method For Particle Size Distributions—*L. M. Cartwright and R. Q. Gregg, Phillips Petroleum Co.*

The Determination of Partizle Size by Gas Adsorption Methods—*R. Jay Fries, Mellon Institute*

Application of Electroformed Micro Mesh Sieves for the Precise Determination of Particle Size Distribution of Cracking Catalysts—*H. W. Daeschner, E. E. Seibert, and E. D. Peters, Shell Development Co.*

Recommended Practice of Reporting Particle Size Characteristics of Pigments (D 1366 – 55 T)—*J. H. Calbeck, American Zinc Sales Co.*

Three-Dimensional Electronic Sizing of Sub-Sieve Particles at 600 per Sec—*R. H. Berg, Process Control Services Co.*

Recent Developments in the Hydrometer Method as Applied to Soils—*E. E. Bauer, University of Illinois*

Particle Size Determination of Tungsten Metal Powders in the 1 to 10 μ Range—*W. H. Bleeker, Allegheny Ludlum Steel Corp.*

The Stanford Research Institute Particle Bank—*R. D. Cadle, Stanford Research Institute*

Symposium on Solvent Extraction in the Analysis of Metals

Sponsored by Committee E-3 on Chemical Analysis of Metals

Metals Analysis with Thenoyltrifluoroacetone—*F. L. Moore, Oak Ridge National Laboratory*

Solvent Extraction of Metals Ions from Acidic Solution with Tri-N-Octylphosphine Oxide—*J. C. White, Oak Ridge National Laboratory*

Convergence of Tie Lines in Ternary Liquid Systems—Application to Liquid Extraction—*R. L. Pilloton, Union Carbide Corp.*

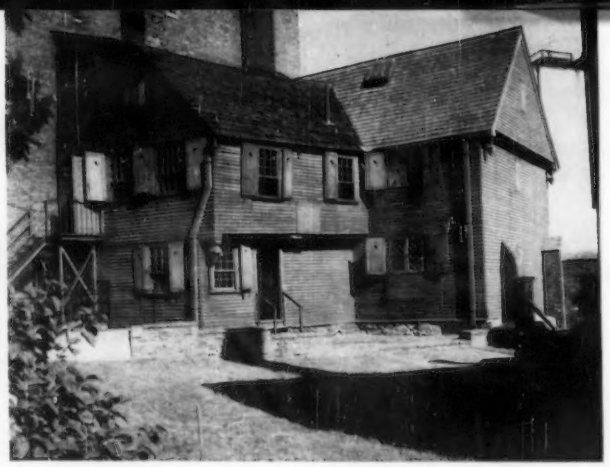
8-Hydroxyquinaldine Extractions Applied to the Analysis of Metals—*R. J. Hynek, Allis-Chalmers Manufacturing Co.*

Solvent Extraction in Flame Spectrophotometry—*J. A. Dean, University of Tennessee*

Symposium on Some Approaches to Durability in Structures

Sponsored by Committee E-6 on Methods of Testing Building Constructions

Some Factors Affecting Durability of Structural Clay Product Masonry—*P. V. Johnson, Structural Clay Products Institute*



A Boston landmark — Paul Revere's house, built in 1660.

Laboratory Testing and the Durability of Concrete—*T. B. Kennedy, U. S. Army Engineer Waterways Experiment Station*

Durability Tests of Structural Sandwich Constructions—*E. W. Kuenzi and L. W. Wood, U. S. Forest Products Laboratory*

Some Aspects of the Durability of Structures—*R. F. Legget, et al, National Research Council*

Effect of the Atmosphere on Masonry and Related Materials—*J. W. McBurney, consultant*

Relation Between Actual and Artificial Weathering—*F. W. Rhinhart, National Bureau of Standards*

Molecular Architecture—*Arthur von Hippel, Massachusetts Institute of Technology*

Instruments in Materials Research—*B. H. Billings, Baird-Atomic, Inc.*

Recent Advances in Polymer Chemistry—*Herman Mark, Polytechnic Institute of Brooklyn*

Modern Liquid Fuels—*A. L. Lyman, California Research Corp.*

Research in Ordnance Materials—*John Antal, Watertown Arsenal*

New Developments in Metallurgy—*John Fisher, General Electric Co.*

Recent Advances and Developments in Glass Technology—*W. W. Shaver, Corning Glass Works*

Symposium on Fundamentals of Fatigue

Sponsored by Committee E-9 on Fatigue

Dislocation Behavior in LiF Crystals During Fatigue—*R. Keith and J. J. Gilman, General Electric Co.*

Cycle-Dependent Stress Relaxation—*Jo-Dean Morrow and G. M. Sinclair, University of Illinois*

Observations Relating to a Proposed Mechanism of Fracture by Fatigue—*W. A. Wood, University of Melbourne*

Internal Friction and Fatigue in Metals—*W. P. Mason, Bell Telephone Laboratories*

A Study of Fatigue Crack Formation in Silver Chloride—*P. J. E. Forsyth, Royal Aircraft Establishment*

Slip-band Formation and Fatigue Cracks of Different Materials under Alternating Stressing.—*M. R. Hempel, Max-Planck-Institut für Eisenforschung*

Fatigue Behavior in Shear of Oriented Magnesium Mono-crystals—*R. W. Armstrong and G. T. Horne, Carnegie Institute of Technology*

Materials Research Frontiers

Sponsored by Administrative Committee on Research and New England Council

Tailoring the Properties of Materials—*E. P. Stevenson, Arthur D. Little, Inc.*

Symposium on Applications of Soil Testing in Highway Design and Construction

Sponsored by Committee D-18 on Soil for Engineering Purposes

Examples of Highway Soil Engineering—*E. S. Barber, University of Maryland*

Subsurface Exploration with Drilling Machines, Power Augers and Earth Resistivity—*D. G. Shurig and E. J. Yoder, Purdue University*

The Soil Exploration and Mapping Cooperative Project in Illinois—*Nicholas Chryssafopoulos, University of Illinois*

Investigation of Banded Sediments Along St. Lawrence-North Shore in Quebec—*R. W. J. Pryer, North Shore and Labrador Railroad, and K. B. Woods, North Shore and Labrador Railroad and Purdue University*

The Growth of Soil Testing in South Europe and the Middle East—*T. J. McNeil, Soiltest, Inc.*

Methods of Compacting Granular Soils—*E. J. Felt, Portland Cement Assn.*

Ohio's Typical Moisture-Density Curves—*J. G. Joslin, State Highway Testing Laboratory*

Soil Classification Scheme Based on Compaction Tests—*J. L. McRae, U. S. Army Engineer Waterways Experiment Station*

The Strength of Compacted Soils—*T. W. Lambe, Massachusetts Institute of Technology*

Laboratory Shear Tests on Varved Clays and Their Application to Design—*R. E. Machol ; University of Connecticut*

Symposium on Radiation Effects on Materials

Sponsored jointly by ASTM Committee E-10 on Radioisotopes and Radiation Effects and Atomic Industrial Forum

The Engineering Test Reactor as an Irradiation Facility—*R. L. Doan, Phillips Petroleum Co.*

Dosimetry Techniques for Gamma and Reactor Radiation Fields—*P. Schall, Jr. and J. F. Kircher, Battelle Memorial Institute*

Fast Neutrons and the EBR-I Core Flow Separator—*R. E. Bailey, Argonne National Laboratory, and M. A. Silliman, Atomic Power Development Associates*

The Effects of Nuclear Radiation on Natural Quartz Piezoelectric Crystals—*F. E. Graham and A. Fueyo, Admiral Corp.*

Irradiation Facilities in NRU—*G. C. Laurence, Atomic Energy of Canada Ltd.*

Radiation Effects on Jet Engine Lubricating Oils—*C. G. Collins, General Electric Co.*

A Description of the Proposed Sandia Engineering Reactor Facility—*J. L. Colp, Sandia Corp.*

An In-Pile Fatigue Testing Apparatus—*E. E. Drucker, Syracuse University*

Some Observations on the Effects of High Neutron and Gamma Fluxes on the Transmission Characteristics of Some Optical Glasses—*J. L. Colp, Sandia Corp.*

Irradiation of Uranium-Fissium Alloys and Related Compositions—*K. F. Smith, Argonne National Laboratory*

Radiation Behavior of Fuel Materials for Sodium Graphite Reactors—*B. R. Hayward, L. E. Wilkinson, and C. C. Woolsey, Atomics International*

Control Materials for Pressurized Water Reactors—*W. Kermit Anderson, D. N. Dunning, and W. E. Ray, General Electric Co.*

Units and Concepts of Radiation Dosimetry—*L. L. Smith, Nuclear Corp. of America*

Reactor Pressure Vessel Design for Nuclear Applications—*N. Balai, Argonne National Laboratory*

Symposium on Bulk Sampling

Sponsored by Committee E-11 on Quality Control of Materials

The Purposes of Bulk Sampling—*W. E. Deming, New York University*

Bulk Sampling Case Histories—*Richard Bingham, Carborundum Co.*

Measurement Error Considerations in Bulk Sampling—*A. J. Duncan, Johns Hopkins University*

The Effect of the Size of the Sample Increment—*W. M. Bertholf, Colorado Fuel and Iron Corp.*

Sample Reduction—*B. A. Landry, Battelle Memorial Institute*

In addition to the above symposia, ASTM Committees will sponsor these sessions:

Concrete and Concrete Aggregates (Committee C-9)
Road and Paving Materials (Committee D-4)
Textile Materials (Committee D-13)
Soils for Engineering Purposes (Committee D-18)

The Lectures Deal with Timely Subjects

Fitted nicely to current national concerns are the topics of the two honor lectures which will be presented at the Annual Meeting by men who are outstanding in their fields.

Elmer W. Pehrson, chief of the Division of Foreign Activities of the U. S. Bureau of Mines is pre-eminently qualified to discuss our nonmetallic materials resources in the Edgar Marburg Lecture.

Clyde Williams, president of Clyde Williams and Co., and formerly director of Battelle Memorial Inst. has been named to give the H. W. Gillett Memorial Lecture on metals. His subject will be high-temperature metals in the jet age—their requirements, properties, and supply.

To the Ladies . . .

Ladies coming to Boston will have an interesting program laid out for their pleasure and entertainment while their husbands are busy with the administrative and technical affairs which make ASTM click.

A committee of ladies from Boston and vicinity, under the chairmanship of Mrs. Miles N. Clair, have planned the following:

Monday morning and every morning through Thursday, there will be a Coffee Hour in the Terrace Room of the Hotel Statler with members of the Ladies' Committee acting as hostesses. The remainder of the day on Monday will be free for personal shopping, sightseeing, or just plain resting and visiting. On Tuesday there will be a tour of the city of Boston extending to Concord, Lexington, and Sudbury, with luncheon at the restored Wayside Inn. A note from the committee indicates that this may be the first luncheon to be served at Wayside after the complete restoration.

On Wednesday there will be a tour of the Gardner Museum with tea served there in the Italian garden. Thursday will offer a choice of two tours, one to the North Shore, including Salem, Saugus Iron Works, and other points of interest, and a luncheon of typical lobster Newburgh at the beautiful new Ocean House at Swampscott. The second one will be to the South Shore to Plymouth in hopes that the Mayflower will be there. The tour will include historic Quincy, the President Adams' home and church, and other historic spots of interest, with luncheon at Hugo's of Cohasset on the ocean.

The ladies will, of course participate in the special luncheons held during the week and in the annual dinner and dance where they will be serenaded by the Boston "Pops" Orchestra under Arthur Fiedler.

More details of the program will be furnished in later editions of the BULLETIN and in a circular letter to members announcing convention details.

Boston Area Laboratories Welcome ASTM Visitors

The Entertainment Committee has arranged for visits to a number of laboratories in the Greater Boston Area for ASTM members attending the Annual Meeting. The laboratories described very briefly below can be visited at some time during the week. Arrangements will be made on an individual basis. The Information Desk at the Statler will supply detailed information and assistance.

GENERAL ELECTRIC CO.

Small Aircraft Engines Dept.—Fully equipped laboratory facilities place special emphasis on high-temperature testing equipment, including creep and rupture testing to 2300 F and a wide variety of fatigue testing equipment for combined stress and component testing.

Aircraft Accessory Turbine Dept.

Turbine, Generator, and Gear Dept.—Materials and processes development, evaluation and application data for production of steam turbines and generators ranging from 2000 to 60,000 kw and for a wide variety of ship propulsion and gearing.

NATIONAL RESEARCH CORP.

Vacuum fusion and vacuum hot extraction laboratory where apparatus and techniques will be demonstrated for analyzing ferrous, non-ferrous, and reactive metals for oxygen, nitrogen, and hydrogen.

BOSTON NAVAL SHIPYARD

The laboratory provides technical support to the Fleet by furnishing metal-

lurgical and chemical services for new construction and repair activities. Also a limited amount of research and development for the Bureau of Ships in cordage, anchor chain, corrosion engineering, and plastics.

QUARTERMASTER RESEARCH AND ENGINEERING COMMAND

Research in chemistry, biology, entomology, climatology, etc., along with facilities for producing test quantities of plastics, rubbers, textiles. Hot and cold chambers for physiological testing and facilities for testing textile fibers, tensile strength of metals, and related apparatus.

BETHLEHEM STEEL CO.

Mechanical and chemical testing, corrosion research, welding and associated metallurgical research, and development of new or improved manufacturing methods

WATERTOWN ARSENAL

A large manufacturing establishment and research laboratory with the responsibility for pilot manufacture and design and fabrication of new Army Ordnance materiel.

HARVARD UNIVERSITY

Laboratories of civil, electrical, mechanical and metallurgical engineering—sanitary, soils, solid state physics and computation (containing three large-scale digital computers of various makes).

UNITED SHOE MACHINERY CORP.

Research Division includes Atomic Power Test Facility featuring high-temperature, high-pressure autoclaves and control systems; projects on electronics, packaging, fasteners, plastics, and power transmission. Manufacturing Division includes an exceptionally complete heat-treating department, inspection equipment including Magnaflux, 300-kv X-ray, dye penetrant, and general mechanical testing.

WESTERN ELECTRIC CO.

Assembly, wiring, testing of Bell System long distance communications equipment. Facilities for heat-treating magnetic materials, modern plating room, comprehensive engineering laboratory.

CBS-HYTRON

A Division of the Columbia Broadcasting System manufactures electronic tubes and semiconductors. This plant produces miniature receiving tubes.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The following laboratories: cyclotron, synchroton, nuclear reactor, IBM 704 computer, acoustics research, wind tunnel, hydrodynamics, electron microscopy.

ESSO STANDARD OIL CO.

The only complete refinery in New England whose refinery units offer the latest types of instruments and controllers. The laboratory's only function is quality control.

BAIRD ATOMIC, INC.

Manufacturers of spectrochemical and radioactivity detection and analytical instruments.

BALDWIN-LIMA-HAMILTON CORP.

Electronics and Instrumentation Div. designs, engineers, and manufactures SR-4 strain gages, SR-4 load cells, SR-4 pressure cells, SR-4 torquemeters, and associated instrumentation.

ARTHUR D. LITTLE, INC.

Application of operations research to production and distribution problems, some pioneering contributions of low-temperature research and gas liquefaction, the pilot fluid bed reactor for metallurgical and chemical processing and use of computing machines to develop low cost processing and structural design.

HIGH-VOLTAGE ENGINEERING CORP.

World's largest radiation and manufacturing test facility where one- and two-million volt radiographic X-ray generators are assembled and tested. Nondestructive testing techniques with supervoltage X-rays will be discussed informally.

There's Nothing Like

BOSTON

By Hal Clancy

BOSTON, HUB OF THE UNIVERSE, imposes an indefinable stamp upon her people . . . No matter what their religious, economic, or political differences, they are all, in time, Bostonians. . .

THIS seems as natural and as right as the traditional baked beans and brown bread on Saturday night . . . as the swan boats, laden with children, paddling sedately on the lake in the Public Gardens . . . as bench sitting on Boston Common in the summer sun . . . as the ever-present east wind, knifing in from the ocean.

LIKE everything else in this city, the unpredictable weather is a source of grim pride to the Bostonian . . . When he says Boston's weather is the trickiest in the world, he is not complaining. He is boasting.

IT is an easy place in which to get lost, if you are a stranger . . . The streets, laid out on old paths and cow walks, twist and turn and double back . . . But this, too, is good—for it is the best way to see Boston.

THE gracious old mansions on Beacon Street . . . the quaint blue-glass windows—here it is Sunday afternoon all week long. A stone's throw away, gaudy Scollay Square with its honky-tonks and tattoo parlors, beloved liberty land of sailors, known in ports throughout the world.

A little farther up Beacon Hill to Louisburg Square . . . landfall of the Most Proper of Bostonians . . . Almost an autonomous island: the aristocratic families living there own the whole square outright, meet once a year to tax themselves, have virtually no responsibility to city government.

NOT far away, the spires of the "Old North Church," where the lanterns were hung for Paul Revere, rise in the turbulent North End of the city. The little stores exude a spicy aroma. It is a poor district, but it abounds with bright colors and good music and superb food . . .

A little farther on . . . sidewalks of glazed brick and red brick and narrow streets of cobblestone—and the Charles River flows silver beneath arched bridges . . . Nearby, the Shell where the Boston Esplanade Orchestra gives its summer concerts for families from all walks of life . . . During the day, myriad bright-colored sailboats dot the Charles . . . Students from Harvard and Massachusetts Institute of Technology, across the water, sun-bathe by the river's edge . . . At night, the lights of Cambridge resemble a luminous pearl necklace above the still, dark water . . .

WALK toward the wind and you will reach the harbor, where the boats come in with bumper loads of cod and haddock and scallops and shellfish . . . Nearby, the old wharfs—India Wharf, where clipper ships once brought exotic spices from Cathay . . .

BOSTON is a city of good living and fine restaurants . . . But Boston is, above all, an attitude—an air of contentment and quiet culture.

Reprinted from *Coronet*, January, 1952
© 1951 by Esquire, Inc.

NEW ASTM PUBLICATIONS

1957 Supplements to Book of Standards

PART 2 on Non-Ferrous Metals of the 1957 Supplements to the Book of ASTM Standards was received from the printer on Dec. 11, 1957. This is the first of seven Supplements to appear, and members who receive this Part on their continuation order should have their copies. Part 6 on Plastics, Electrical Insulation, Rubber, Electronic Materials, and Carbon Black was published on Jan. 8, 1958. The five remaining Parts are scheduled for publication between the date this is written and March, and the last Part should be off the presses late in March.

These and the 1956 Supplements together with the 1955 Book of ASTM Standards contain all of the Society's up-to-date standards and tentatives with the exception of those appearing in the Chemical Analysis of Metals, a separate book published in 1956.

The constant growth in the use of the Society's standards makes each issue of the Book of Standards larger than those which have appeared before. It has been necessary this year to reprint Part 1 of the 1955 Book to supply the unusual demand.

We have already announced that in 1958 the size of the Book of Standards will be increased to 10 Parts with appearance of the various Parts scheduled in the period late October, 1958, to March, 1959.

Compilations of Selected ASTM Standards

Textiles.—In addition to the 128 specifications and methods of test developed by ASTM Committee D-13, this publication also contains 16 proposed methods of test, three of which have not previously been published: (1) Length and Length Distribution of Cotton Fibers by the Short Method Array; (2) Estimating Maturity and Weight per Unit Length of Cotton Fibers by the Causticarre Method; and (3) Sampling and Preparation of Test Specimens from Wool Fabric and Yarns for Determination of Fiber Fineness. 800 pages. Price: $7.25; to members, $5.50.

Adhesives.—51 specifications and methods of test prepared by Committee D-14 plus Proposed Methods for Measurement of Tack of Adhesives and for Bonded Specimens of Adhesives as Cantilever Beams Under Repeated Constant Deflection. 252 pages. Price: $3.50; to members, $2.80.

Wires for Electrical Conductors.—55 standards under the jurisdiction of Committee B-1. 344 pages. Price: $3.75; to members, $3.

Electron Tubes and Semiconductor Devices.—41 specifications, definitions, and methods of test, under the jurisdiction of Committee F-1. 256 pages. Price: $3.50; to members, $2.80.

Symposium on Large Fatigue Testing Machines and Their Results

To date, most of our knowledge of fatigue of materials has come from tests on relatively small specimens that bear little resemblance to the part being tested. But the nine papers in this symposium which was held at the 1957 ASTM Annual Meeting demonstrate the practical value in carrying out fatigue tests on actual components.

These papers submitted by the aircraft, electrical, marine, railroad, and earth removal industries represent a cross-section of full-scale fatigue work in America today. The two papers submitted by engineers from the Academy of Science, Moscow, U.S.S.R., give an insight into some of the work being conducted in the Soviet.

The symposium makes available valuable data on the effect of size on the fatigue strength of plain specimens. Also such effects as stress-concentration and fretting corrosion of large-size sections are examined. The experimental difficulties connected with the fatigue testing of large specimens are considerable, and the tests are expensive and time consuming. In this light, the material presented in this symposium will greatly enhance the literature.

Titles and authors of papers are as follows:

Introduction—J. M. Lessells
A Unique Machine for Large Scale Fatigue Testing—H. V. Cordiano
Torsion Fatigue Testing of Axle Shafts—E. J. Eckert
Fatigue Testing of Airframe Structural Components—H. W. Foster
Fatigue Performance of Marine Shafting—Laboratory and Service Test—T. W. Bunyan
Fretting Corrosion of Large Shafts as Influenced by Surface Treatments—O. J. Horger and H. R. Neifert
Fatigue Tests of Large Alloy Steel Shafts—F. C. Eaton
Influence of Operating Experience and Full Scale Tests on Propulsion Shafting Design of U. S. Navy Ships—R. Michel
Sudden Fracture of Machine Parts and Structure Elements—G. V. Uzik, M. J. Galperin, and A. A. Zooykova
Dynamical Loading in Full Size Fatigue Tests and Some Results—S. V. Serensen and M. E. Garf

STP 216; 162 pages. Price: $4.25; to members, $3.40.

Symposium on Radioisotopes

The use of radioisotopes in industry is becoming legend, saving many millions of dollars each year in terms of process and product improvements and knowledge gained. Industrial groups are employing radioactive tracers to unravel processing mysteries, radiation gages to improve process control, and are interested either in harnessing radiation to create new products or in evaluating the effect of radiation on the performance of their products for reactor use.

ASTM Committee E-10 was created some years ago to be of service to other ASTM groups as an adviser in the rapidly changing atomic energy scene and to bring thought-provoking and educational information before the general membership of ASTM. This symposium, which was held in Los Angeles at the Second Pacific Area National Meeting in 1956, is part of this program bringing contributions from some of the most prominent people in their respective fields.

Titles and authors of the papers included in this publication are as follows:

Introduction—C. E. Crompton
Electroplating and Metal Preservation Studies Utilizing Radioisotopes—S. L. Eisler
Evaluation of Rubber Deterioration by Means of Phosphorus-32—J. F. Young and C. W. Richards
Autoradiography as a Testing Technique—M. J. Schlesinger and H. J. Gomberg

Use of Radioactive Tracers in the Study of Soil Removal and Detergency—E. B. Ashcraft

Refinery Scale Applications of Radioactive Tracers—V. P. Guinn, H. R. Lukens, Jr., and C. D. Wagner

Activation Analysis for Industry—Abel DeHaan

Thickness, Density, and Concentration Gaging with Radioisotopes—R. L. Newacheck, J. Kohl, and D. L. Forrest

Will ASTM Standards be Influenced by Radiation Effects in Metals?—J. C. Wilson and R. G. Berggren

The Problem of Establishing Specifications for Irradiated Organic Materials—O. Sisman

General Discussion—P. C. Aebersold

STP No. 215; 100 pages. Price: $2.75; to members, $2.20.

Determination of Dissolved Oxygen in Water

The concentration of dissolved oxygen in water is an important consideration for water used in both biological and industrial processes. Not only is it necessary to know the exact concentration at intervals, but in many processes it is necessary to guard against momentary or periodic variations in the concentration.

This symposium, held at the 1957 ASTM Annual Meeting presents the best current information on methods and apparatus for determining dissolved oxygen in water including both the manual spot-check methods and those using instruments providing continuous indication and record. The authors discuss the principal advantages and disadvantages of their respective procedures and apparatus, indicating the conditions under which each can be most appropriately applied:

Titles and authors of the papers are as follows:

A Study of the Accuracy of Methods of Testing for Dissolved Oxygen in High-Purity Water—K. G. Stoffer, Arabian American Oil Co.

Polarographic Measurements of Dissolved Oxygen—W. W. Eckenfelder, Jr., and Conrad Burris

The Beckman Dissolved Oxygen Analyzer—Thomas Finnegan and R. C. Tucker

Evaluation of Hartmann and Brau Dissolved Oxygen Recorder for Boiler Feedwater—A. J. Ristaino and A. A. Dominick

Determination of Dissolved Oxygen by Means of a Cambridge Analyzer—H. A. Grabowski

STP No. 219; 64 pages, Price: $2.25; to members, $1.80.

Papers on Cement and Concrete

Cement and concrete, major construction materials, received their share of attention at the Second Pacific Area meeting in Los Angeles in September, 1956. The two sessions sponsored by Committees C-1 on Cement and C-9 on Concrete, included topics not commonly discussed in technical papers, such as hydrophobic cement, along with the more familiar subjects such as the effect of aggregate on the resistance of concrete to abrasion.

The titles of the papers, listed below, indicate the scope of the coverage in this publication:

Effect of Storage on Air-Entraining Cements—W. J. McCoy and S. B. Helms

Hydrophobic Cement—U. W. Stoll

Carbonation of Hydrated Portland Cement—G. Verbeck

The Partial Replacement of Portland Cement in Concrete—Bryant Mather

Alkali-Aggregate Phase of Chemical Reactivity in Concrete, Part II—J. A. Hester and O. F. Smith

The Effect of Aggregate Quality on Resistance of Concrete to Abrasion—F. L. Smith

Test of Prestressed Expanded-Shale Concrete Beams Subjected to Short-Time and Sustained Loads—R. E. Davis, G. E. Troxell, D. O. McCall, and R. A. McCann

A Physical Method for Determining the Composition of Hardened Concrete—J. W. Kelly, M. Polivka, and C. H. Best

STP No. 205; 158 pages. Price: $4; to members, $3.20.

Staff Pension and Insurance Benefits Amplified

Since 1938 there has been in effect a contributory pension plan for those members of the ASTM Headquarters Staff who wish to participate. As the Staff grew, the number of participants increased, and early in 1956 about half of the regular Staff were covered by the plan. Studies by the Finance Committee in collaboration with a leading pension actuary and a legal firm skilled in this field resulted in changes in the plan which became effective in May, 1957. This plan has been approved as complying with the various regulations established by the Internal Revenue Service.

The biggest change was the dropping of individual annuity policies and the funding of the plan with the Girard Trust Corn Exchange Bank Pension Fund. This obtains the benefits of a large and growing fund in which a number of leading Philadelphia companies participate. The individual policies previously issued are a part of the funding. Pension benefits were increased, and coupled with the plan although not an essential part of it, is a revised and modified group life insurance plan. All Staff members have been covered by a group life insurance policy, which is provided employees at no cost. The Society also underwrites the cost for regular Staff members of a hospitalization plan and a major medical plan. Further details of the new pension plan will be embodied in the 1958 Annual Report of the Directors.

Actions on Standards

The Administrative Committee on Standards is empowered to pass on proposed new tentatives and revisions of existing tentatives and tentative revisions of standards offered between Annual Meetings of the Society. On the dates indicated the Standards Committee took these actions:

METHODS OF TESTING

Definitions with Procedures Relating to Conditioning and Weathering (E 41 – 48 T) (Approved Dec. 23, 1957)

Revision.—Tolerances on the established temperature for standard laboratory atmosphere are changed from 1.1 C (2 F) to 1 C (1.8 F). Committee E-1 has recommended this change in the interest of having a single degree tolerance of temperature in the Centigrade scale rather than a fractional tolerance, primarily for international use.

Tentative Specifications for Weighing and Drying Apparatus for Microchemical Analysis (E 124 – 56 T) (Approved Dec. 23, 1957)

Revision.—Added to these specifications are requirements for a micro glass desiccator with metal insert. Also included are some minor revisions of the Modified Abderhalden drying apparatus as a result of experience since the specifications were first published.

Tentative Methods of Tension Testing of Metallic Materials (E 8 – 54 T) (Approved Dec. 26, 1957)

Revision.—Various changes have been made in these methods to bring them in closer agreement with Methods and Definitions for Mechanical Testing of Steel Products (A 370 – 54 T) prepared by Committee A-1 on Steel.

ASTM Bulletin

FEBRUARY 1958

NO. 228

NINETEEN-SIXTEEN
RACE STREET
PHILADELPHIA 3, PENNA.

Membership—ASTM Lifeblood

1957 Increase Second Highest

THE LIFEBLOOD of ASTM is its members. Not only do they help the Society meet its financial obligations through their dues, but they constitute in their technological abilities a tremendous reservoir of scientific knowledge and experience. It is the latter invaluable contribution of its members that provides American industry with the results of specialized research in materials, and finds form in our standards. Consequently, ASTM officers at all levels have always concerned themselves with the number and quality of ASTM membership.

The Board of Directors maintains a standing membership committee whose function it is to survey continually the membership position of the Society, based on data collected by the Headquarters staff. These data, and policy recommendations based thereon, help the Directors to plan adequately for those forthcoming developments in the Society that relate to membership.

A summary example of the statistics used by the Membership Committee in its planning is the cumulative picture of gains and losses in the several member categories. Total new members in 1957 managed to break 1000 again, for the second best year we have had (1956 was slightly better). These were divided among Sustaining (4), Corporation (173), Individual (741), and Associate (84). In addition, Student Members, our seed crop for the future, showed a strong upsurge, rising from a total of 793 last year, to 1238 this year. Much of this growth can be credited to the Student Membership Prize Award Program, which is being fostered by most of the District Councils. Consequently ASTM has reached a new high in membership of 9159 for the year ending November 30. Student membership of 1238 must be added to this figure.

An analysis a few years back to determine the stimulus causing technical people to apply for individual membership in ASTM showed that, although Headquarters publicity and contacts accounted for most—30 per cent—fully 20 per cent were influenced by discussions with colleagues who were already members. (Recognizing the importance of the latter source of members, President Kropf has urged, in a recent letter, all possible effort in this direction; to assist each of us in suggesting qualified candidates a return card was provided for listing names and addresses.) Another 20 per cent are, so far as can be learned, unsolicited applications stemming from a direct need for the knowledge and services provided by the Society. A final 30 per cent is difficult to classify, but may fall partly into some of the above categories.

Membership losses from ASTM are equally important to the Membership Committee, hence are studied with equal care. In general, our loss rate is less, or in some instances no greater, than in similar technical organizations. Reasons are varied, including change of job, retirement, change of interest, etc.

One of the important responsibilities shared by the Directors, the Technical Committees, and individual members alike is to incorporate the knowledge and capabilities for work brought to the Society by new members into the coordinated technical power of ASTM with minimum delay. Indoctrination of neophytes into the mysteries of ASTM workings, has been accelerated by a short explanatory booklet. Within the limitation of consumer-general interest *versus* producer balance of voting members, Technical Committees can help by assisting new members to find cooperative work that fits their interests and backgrounds. Finally, each of us, as an individual member, can ease the orientation period and thus prevent the discouragement that sometimes arises from the difficulties attendant in learning the whys and ways of things we do.

Schedule of ASTM Meetings

This gives the latest information available at ASTM Headquarters. Direct mail notices of all district and committee meetings customarily distributed by the officers of the respective groups should be the final source of information on dates and location of meetings. This schedule does not attempt to list all meetings of smaller sections and subgroups.

Date	Group	Place
March 3	Committee E-13 on Absorption Spectroscopy	Pittsburgh, Pa. (Penn Sheraton Hotel)
March 5-7	Committee D-1 on Paint, Varnish, Lacquer and Related Products	Louisville, Ky. (Kentucky Hotel)
March 5-7	Committee C-16 on Thermal Insulating Materials	Hollywood, Fla.
March 6	Committee E-2 on Emission Spectroscopy	Pittsburgh, Pa. (Penn Sheraton Hotel)
March 10-11	Committee D-12 on Soaps and Other Detergents	New York, N. Y. (Park Sheraton Hotel)
March 18-21	Committee D-13 on Textile Materials	Washington, D. C. (Sheraton Park Hotel)
March 19	Chicago District	Chicago, Ill. (Stockyards Inn)
March 20	Washington, D. C., District	Washington, D. C. (Sheraton Park Hotel)
March 25	Committee E-12 on Appearance	Washington, D. C. (National Bureau Stds.)
March 26-28	Committee D-15 on Engine Antifreezes	Washington, D. C. (Shoreham Hotel)
April 1	Committee C-3 on Chemical Resistant Mortars	Philadelphia, Pa. (ASTM Headquarters)
April 2-3	Committee D-14 on Adhesives	Madison, Wis. (Forest Products Lab.)
April 10-11	Committee C-23 on Sorptive Mineral Materials	Detroit, Mich. (Hotel Statler)
May 26-27	Committee D-10 on Shipping Containers	New York, N. Y. (Statler Hotel)
June 2-6	Committee E-14 on Mass Spectrometry	New Orleans, La. (Hotel Jung)
June 22-28	**Annual Meeting**	**Boston, Mass. (Statler and Sheraton Plaza Hotels)**

ASTM Finances in 1957

Modest Deficit Not Unexpected

ALTHOUGH our budget operations for 1957 (Dec. 1, 1956, through Nov. 30, 1957) resulted in a deficit of about $7500, this was much less than had been anticipated, and the Finance Committee and Directors feel encouraged with the financial operations.

As stated frequently, the Society's financial operations should be considered over a three-year period. Because of the tremendous influence of the triennial issue of the Book of ASTM Standards, the major income is derived in the year following its publication. Income is considerably reduced in the second and third years, and '57 was a second year. Details of income and outgo are shown in the accompanying tables. The 1958 Budget anticipates a moderate deficit of about $45,000. Some further details shown in this article will be given in the Annual Report of the Board of Directors when presented to the Society on June 24 at the Annual Meeting in Boston.

1957 Receipts. In all three main categories—dues and entrance fees, sales of publications, and miscellaneous—receipts exceeded the budget by almost $80,000, totalling about $1,021,000. It will be noted that dues and fees represent about 27.7 per cent of income. (Much different from figures of 10 to 15 years ago when dues accounted for 50 per cent or more of income.) Current figures do not mean fewer members but rather wider distribution of our books.

1957 Disbursements. Total costs of about $1,028,000 were over the budget by about $11,000. It must be noted that this figure includes a $75,000 reserve for the '58 Book of Standards not actually to be spent until next year; and also $83,000 to be spent in 1958 to cover the current *Proceedings* and the '57 Standards' Supplements. Including the reserves for future publications, costs reached about $430,000. Salary expenditures were about $360,000.

Assets and Surplus. Total assets on November 30 were $1,664,000 which includes general and also special funds. The surplus declined to $429,900—less than half our annual expenditures.

Investments. Major changes in the combined ASTM Investment Fund were in the direction of more bonds as of November 15. The book value of the investments was about $787,500, the market value, about $875,400.

1958 Budget. Despite the fact that '58 is really the third year in our Book of Standards period, the Finance Committee believes that total

Income $1,020,700

(This is down about $60,000 from last year when we benefited from the heavy first-year sales of the Book of Standards. However, all main categories were well over the budget.)

Spent—$1,028,200

(Many publications net heavy printing bills but this will continue as we issue more information on the properties of materials. This figure also includes nonexpended reserves for the next Book of Standards and for the *Proceedings*.)

Net—A not discouraging deficit of $7500

(This is about $\frac{1}{10}$ of that which had been expected.)

Total Assets—$1,663,500

(This is up about $190,000.)

Surplus—$429,900

(This is down from last year and represents only about 44.1 per cent of the full year's disbursements.)

OPERATING RECEIPTS

Source	1957		1956		1955		1954	
		Per cent		Per cent		Per cent		Per cent
Dues	$283 389	27.7	$268 985	25.0	$252 072	29.6	$236 345	29.8
Sales of Publications	623 936	61.2	695 950	64.0	521 496	61.3	470 459	59.2
Miscellaneous								
Advertising	54 326	5.3	43 324	...	31 994	...	28 214	...
Interest and Dividends	30 492	3.0	29 798	...	27 162	...	23 754	...
Registration Fees	16 404	1.6	16 622	...	13 701	...	12 581	...
Exhibit	2 950	0.3	20 168	...	750	...	16 144	...
Other	9 183	0.9	7 704	...	4 628	...	7 048	...
Total Miscellaneous	113 355	11.1	117 617	11.0	78 235	9.1	87 741	11.0
TOTAL RECEIPTS	$1 020 680	100.0	$1 082 552	100.0	$851 803	100.0	$794 546	100.0

OPERATING DISBURSEMENTS

Item	1957		1956		1955		1954	
		Per cent		Per cent		Per cent		Per cent
Publications	$430 175	41.9	$342 323*	38.1	$349 963†	41.2	$277 346	36.9
Salaries	360 171	35.2	309 402	34.3	305 362	35.8	276 855	36.9
General Office Expense	93 079	9.1	111 557	12.5	83 342	9.8	79 802	10.6
Meetings and Technical District Committees	29 054	2.7	42 206	4.8	27 121	3.2	33 270	4.4
Headquarters Occupancy	41 089	4.0	35 582	4.0	35 319	4.1	31 035	4.2
Retirement, Health	49 672	4.8	32 603	3.7	32 855	3.9	27 429	3.6
Miscellaneous	24 922	2.3	22 840	2.6	17 390	2.0	25 250	3.4
TOTAL DISBURSEMENTS	$1,028,162†	100.0	$896 513	100.0	$851 352	100.0	$750 987	100.0

* Does not include $85,000 earmarked as a reserve for the 1958 Book of Standards, and not expended.
† Includes $75,000 for 1958 Book of Standards Reserve plus $83,000 to cover estimated costs of 1957 *Proceedings* and 1957 Supplements to 1955 Book of Standards.

income might reach $1,065,000, about $660,000 of which will come from sales of publications. Total disbursements will probably reach about $1,110,000. Any deficit will be made up from surplus. Details are shown in the accompanying budget summary tables.

The Finance Committee believes the Society to be in a healthy financial condition. Every effort is made to have our dollars do the maximum in carrying forward the purpose of the Society to promote research and standards for materials. While the total budget may not be impressive compared with many others we read about in the daily press, considering its catalytic action in stimulating tremendous contributions from industry and Government agencies through the services of the country's top technical people, the use of laboratories, etc., ASTM continues to pour into the stream of technical advancement a continually increasing volume of essential information.

1958 BUDGET SUMMARY

Estimated Receipts

		Per cent
Dues and Entrance Fees	$287 000	27.0
Publications	660 500	62.0
Miscellaneous	117 500	11.0
TOTAL CURRENT RECEIPTS	1 065 000	100.0
From Surplus	45 000	
	$1 110 000	

Estimated Disbursements

		Per cent
Publications	$451 000	40.6
Salaries	395 000	35.6
General Office Expenses	101 000	9.1
Technical Committee Expenses	12 000	1.1
Meetings	30 500	2.7
Headquarters Occupancy Expenses	41 000	3.7
Retirement Insurance Expense	48 500	4.4
Miscellaneous Expenses	31 000	2.8
TOTAL OPERATING DISBURSEMENTS	$1 110 000	100.0

Central New York Section Studied

Letters soliciting the comments of over 300 members and committee members in central and upstate New York have been sent out to determine the feeling of the members in this area toward forming a Section to support ASTM activities. The comments elicited from the members will determine whether or not sufficient enthusiasm is available for a continuing organization in this area.

ACR Notes

Administrative Committee on Research

Communicating Research Results

By FRANK Y. SPEIGHT[1]

THERE is no question that the rapid advance in science and technology in recent years could not have taken place without adequate scientific and technical communications. For each advance is based upon recorded knowledge—the results of research.

It is indeed fortunate that some of the most able scientists and engineers are also capable writers in their fields. Unfortunately there are others who apparently feel that once the research is accomplished there is no need to communicate results to others, or that the job of writing a report should be for someone who is good at writing but who has no special knowledge of the subject. This introduces problems of communication between the technologist and the writer. It is better, we feel, for the researcher himself to prepare his report and then to depend on editorial assistance where necessary.

When research budgets are being prepared, a special item should be included to cover the time and the expense of preparing a report of the research for publication. With such advance planning it can be assured that the results of the research will not be lost. This point was made emphatically by A. T. McPherson at the meeting in December of the Administrative Committee on Research, with general concurrence by other members of the ACR. Certainly if the research is worth doing, it is worth reporting.

Responsibility of Editors and Reviewers

It is becoming increasingly difficult for technologists to keep up with publications even within a limited field because of the logarithmic growth of technical publications. It is the responsibility of editors and the reviewers of technical papers to make sure that the paper or similar information has not been published previously, and that either the data or the interpretation are original. Such a policy reduces the total volume of technical literature without reducing its technical content.

[1] Secretary, Administrative Committee on Research.

Research Reviews

To help the searcher in the literature it has become a regular practice in most technical fields to publish annual reviews of the literature. In effect, these annual reviews amount to annotated bibliographies. Some are published as books and others appear in special issues of technical periodicals. There is no question that they do a great deal of good in assisting researchers in keeping up with what others are doing.

In ASTM, research is given equal weight with development of standards for materials. It has been often repeated that ASTM standards have gained the degree of acceptance and authority they have because of the sound research upon which they are based. However, on reading the standards the research background is not always apparent. Some standards carry pertinent literature references at the end; most, however, do not.

It might be assumed that at least those companies represented on ASTM technical committees would be aware of the research background for standards. Many other organizations not represented on the committees are not expected to know about the research background unless it is adequately publicized.

One of the functions of the ACR is to review periodically the research of the Society. The most recent comprehensive review was published as a special pamphlet in 1953. Plans are afoot for another comprehensive review in 1958 and the officers of technical committees have received a letter and a questionnaire requesting their participation in preparing another comprehensive review of ASTM research. This review will be subdivided into appropriate materials categories—metals, construction materials, organic materials and chemicals, analysis and testing, electrical and electronic materials, etc.—and published in separate issues of the ASTM BULLETIN. Reprints of these reviews will later be combined into a separate publication covering the 1958 *Review of ASTM Research*.

Technical Committee Notes

Wax Polishes and Related Materials

Work in Measurement of Slip Resistance Fully Reported

For seven years, Committee D-21 has studied mechanical apparatus and procedures for the measurement of slip resistance of waxed floor surfaces. At the meeting held on January 21, in New York City, the committee presented a report reviewing the work to date on this subject. Although the committee members have tested a variety of mechanical devices, the James and Sigler Machines (which were described in ASTM Bulletin, No. 196, p. 20 (February, 1954)) have received the greatest attention. These machines measure different aspects of the coefficient of friction, in terms of the shoe sole, the floor wax used, and type of flooring materials. Since the coefficient of friction is only one factor in the determination of slip resistance of waxed floors, data from these machines cannot be directly correlated to floor safety. In addition, new types of wax formulations have affected the coefficient of friction as measured by these machines in a manner contradictory to field tests. A full report reviewing the committee's experience with machines for determining floor safety is now being prepared and will appear in a forthcoming issue of the Bulletin.

The data from the first interlaboratory collaborative test program to measure the effects of damp mopping on the removability of aged wax films were presented to the committee. This program utilized four types of floor waxes under five aging conditions. The results of this program will serve as a basis for a second test program now in preparation.

Methods in various stages of preparation which were reviewed include: total solids of solvent and paste-type waxes, water spotting of applied wax films, and the service life of wax film. A new collaborative test program on storage stability of water-emulsion floor wax preparations was presented. This test program, which is designed to reduce the number of variables of the previous program, involves a 60-day oven test, and a one-year room temperature test and will utilize eight types of water-emulsion floor waxes.

Kennedy to Receive DeWitt Smith Medal

Stephen J. Kennedy, research director, Textile, Clothing, and Footwear Division, Quartermaster Research and Development Center, Natick, Mass., has been named the 1958 recipient of the H. De Witt Smith Memorial Medal of ASTM Committee D-13 on Textiles. The presentation will be made on March 20, 1958 during the spring meeting of Committee D-13 at the Sheraton-Park Hotel in Washington, D. C.

The medal is a testimonial to the memory of the late Harold De Witt Smith who pioneered in the concept of an engineering approach to the evaluation of the properties of textile fibers and their utilization. It was endowed by Fabric Research Laboratories, Inc., Boston, and is awarded at intervals of not less than one year by the Textile Committee for outstanding achievement in research on fibers and their utilization. This is the ninth time the medal has been awarded.

Dr. Kennedy has had a distinguished career in the service of the U. S. Army Quartermaster Corps since 1942. In that year as Lt. Colonel, he became chief of the Textile Section, Research and Development Branch, Military Planning Division, O.Q.M.G. In this capacity he initiated the Q.M. program of research and development in the field of textiles and successfully sought and utilized the cooperation of the textile industry, foremost scientists, and laboratories in designing and developing improved clothing and shelter for American soldiers. For his wartime accomplishments he was cited for the Legion of Merit.

Industrial Water

Three Methods Cleared for Presentation at Annual Meeting

More than 20 new methods for testing industrial water were studied at the Committee D-19 meetings held January 12 to 15 in New Orleans, La. Methods for measurement of surface tension, for determination of dissolved and gaseous hydrogen, and for evaluating the effect of water on tubular metallic heat exchangers (corrosivity, deposit-forming tendency, etc.) should be ready for submittal to the Society at the 1958 Annual Meeting, for publication as tentative. Among the more significant of the other new projects are a method of sampling industrial waste water containing floating matter, a test for silica in high-purity water, measurement of radioactivity in water, and radioactive tracer techniques for constituents of industrial water.

A method for preparation of water having a standardized dissolved oxygen content was reported. When some further work on this method has been completed, it will provide the basis for a new, more precise evaluation of the various methods of test for dissolved oxygen, which may result in revisions in the Methods of Test for Dissolved Oxygen in Industrial Water (D 888 – 49 T).

The Method of Identification of Types of Microorganisms in Industrial Water (D 1128 – 50 T) will be completely rewritten.

The report of progress on a Second Edition of the Manual on Industrial Water indicates that most of the material will be completed in 1958 and that the new edition will be ready for publication in 1959. A Fourth Printing of the First Edition is now available.

The committee reviewed preparations for a symposium on radioactivity in industrial water that is being planned for presentation at the 1958 Annual Meeting of the Society. Preliminary plans were made for a symposium on water-formed deposits, preferably to be arranged for the 1959 Annual Meeting of the Society, and for a symposium to be held at the 1959 Pacific Area Meeting in San Francisco.

SERIES 3

New SBR Numbers

Assignments by Committee D-11 on Rubber

CODE numbers have been assigned for three styrene-butadiene latices (SBR) by Committee D-11 on Rubber and Rubber-Like Materials on the recommendation of its Subcommittee XIII on Synthetic Elastomers. These new code numbers SBR 2107, SBR 2108, and SBR 2076 will be included in the Tentative Recommended Practice for Description of Styrene Rubber (SBR) and Butadiene Rubber (BR) Latices (D 1420 – 56 T) after approval by letter ballot of Committee D-11. The product descriptions of these three styrene-butadiene (SBR) latices are shown in Table I.

Committee D-11 has also assigned a new code number to a styrene-butadiene rubber (SBR) for inclusion in the Tentative Recommended Practice for Description of Types of Styrene Rubbers (SBR) (D 1419 – 56 T). The code number assigned is SBR 1805 and the product description is given in Table II. This new code number is likewise subject to approval by letter ballot of Committee D-11.

TABLE I.—DESCRIPTION OF TYPES OF STYRENE-BUTADIENE (SBR) LATICES—ASSIGNMENT OF NEW CODE NUMBERS—ASTM D 1420 – 56 T.

Number As Assigned	2107	2108	2076
Date assigned	9/27/57	9/27/57	10/22/57
Requested by	Shell Chemical Corp.	Goodyear Tire & Rubber Co.	Goodyear Tire & Rubber Co.
Distinctive feature	44% bound styrene	Non-discoloring carbamate shortstop	Nondiscoloring shortstop
Close previous number, if any	GR-S X767	GR-S X765	..
Type	2107	2108	2076
Nominal temp., deg F	50	43	122
Activator	FRA	FRA	..
Shortstop	ND	ND	ND
Catalyst	OHP	OHP	P
Emulsifier	mixed	FA	FA
Nominal conversion, per cent	60	60	72
Nominal Mooney viscosity, ML-1 + 4(212 F)—polymer	140	..	50
Nominal residual volatile, unsaturate, per cent	0.1	0.1	0.1
Nominal pH value	10	11	9.0
Nominal surface tension, dynes per cm	..	..	68
Nominal coagulum on No. 80 screen, per cent	0.3	0.10	..
Nominal bound styrene, per cent	4	23.5	23.5
Nominal total solids, per cent	61	40	27

NOTE—Abbreviations and symbols are defined as follows: FA = fatty acid, FRA = free radical type, that is iron-pyrophosphate peroxamine sulfoxylate, ND = nondiscoloring, OHP = organic hydroperoxide, P = persulfate.

TABLE II.—ASSIGNMENT OF NEW CODE NUMBERS—ASTM D 1419 – 56 T—DESCRIPTION OF TYPES OF STYRENE-BUTADIENE RUBBERS (SBR).

Number Assigned	1805
Date assigned	12/18/1957
Requested by	Phillips Petroleum Co.
Distinctive feature	Antioxidant NST: high naphthenic oil and high HAF black
Close previous number	Philprene 6600
Type	1805
Nominal Temperature, deg Fahr	43
Activator	FRA
Shortstop	ND
Antioxidant	NST
Catalyst	OHP
Emulsifier	mixed
Nominal Bound Styrene, per cent	23.5
Nominal Conversion, per cent	60
Nominal Mooney Viscosity, ML 1 + 4 (212 F) polymer	..
Nominal Mooney Viscosity, ML 1 + 4 (212 F) compound	58
Coagulation	SA
Carbon Black Type	HAF
Carbon Black, per cent	35.3
Oil Type	NAPH
Oil Parts	37.5
Finishing	Normal

NOTE.—Abbreviations and symbols are defined as follows: FRA = free radical type, that is iron-pyrophosphate peroxamine sulfoxylate, ND = nondiscoloring, NST = nonstaining, OHP = organic hydroperoxide, SA = salt-acid, HAF = high abrasion furnace, NAPH = Naphthenic.

ASTM-GSA Contract Covers Entire List of Standards

FOR THE third consecutive year ASTM has contracted with the General Services Administration, Federal Supply Service, to provide ASTM standards at special prices to Government agencies. In previous years the list covered only a selected group of about 500 standard specifications and methods of test, but this year it includes the entire list of 2300 or more ASTM standards. The authorized price list is being distributed to a list of about 2200 agencies served by the GSA, Federal Supply Service. A limited supply of additional price lists remaining at Society Headquarters will be sent to Government supply agencies on request so long as the supply lasts.

OTHER SOCIETIES' EVENTS

March 11–13—**American Railway Engineering Assn.,** Annual Meeting, Sherman Hotel, Chicago, Ill.

March 17–18—**Steel Founders' Society of America,** Annual Meeting, Drake Hotel, Chicago, Ill.

March 17–21—**National Assn. of Corrosion Engineers,** Civic Auditorium, San Francisco, Calif.

March 17–21—**Nuclear Congress,** Coordinated by Engineers Joint Council, International Amphitheater, Chicago, Ill.

March 25–26—**Inter-Society Color Council,** 27th Annual Meeting, Sheraton-Park Hotel, Washington, D. C.

March 26–29—**National Science Teachers Assn.,** Annual Convention, Shirley-Savoy Hotel, Denver, Colo.

March 31—April 2—**Gas Appliance Manufacturers Assn.,** Annual Meeting, The Greenbrier, White Sulphur Springs, W. Va.

April 13–18—**American Chemical Society,** Spring Meeting, San Francisco, Calif.

April 14–18—**American Welding Society,** Annual Meeting and 6th Welding Show, Statler Hotel and Kiel Auditorium, St. Louis, Mo.

April 20–25—**American Water Works Assn.,** Dallas, Tex.

April 20–26—**Society of Motion Picture and Television Engineers,** Ambassador Hotel, Los Angeles, Calif.

April 21–23—**Building Research Institute,** 7th Annual Meeting, Shoreham Hotel, Washington, D. C.

April 21–23—**American Oil Chemists Society,** Spring Meeting, Memphis, Tenn.

April 27–May 1—**The Electrochemical Society,** Statler Hotel, New York, N. Y.

May 4–7—**Air Conditioning and Refrigeration Institute,** Annual Meeting, The Homestead, Hot Springs, Va.

May 5–7—**American Mining Congress,** Coal Convention, Netherland Hilton Hotel, Cincinnati, Ohio.

May 11–14—**National Assn. of Purchasing Agents,** Chicago, Ill.

May 12–14—**Council of Engineering Societies Secretaries,** Annual Meeting, The Cleveland Hotel, Cleveland, Ohio.

Services of the Cement Reference Laboratory Extended to Concrete

THE Cement Reference Laboratory has, since 1929, when it was founded, been inspecting laboratories of cement producers and major consumers and independent laboratories for the purpose of giving freely requested assistance and instruction in the correct testing of cements.

Operating from headquarters at the National Bureau of Standards, Washington, D. C., and supported jointly by the Bureau, the American Society for Testing Materials, the Bureau of Public Roads, and the U. S. Corps of Engineers, the Cement Reference Laboratory (CRL) has been a major factor in bringing about a satisfactory degree of uniformity and voluntary agreement among the producers and consumers of cement and concrete with regard to the methods of testing of cements.

From 1929 until 1955, the Cement Reference Laboratory was under the able guidance of John R. Dwyer who, on his retirement two years ago, was succeeded by J. R. Dise. During the period of his leadership, Mr. Dwyer brought the CRL activity to such high standards of competence, objectivity, and authority that no serious question has ever been raised by a cement producer or consumer as to the correctness, the usefulness, or the impartiality of CRL findings and reports concerning the condition of any laboratory.

In recent years, there has been much pressure upon CRL to include in its work the inspection of laboratories which test concrete, a field in which unfortunately, there is more variation and less agreement than is to be found in the testing of cements. It has finally been agreed upon by all parties that support the operations of CRL that this additional work be undertaken beginning on March 1, 1958, and, like the inspection of cement testing laboratories, will be undertaken on the voluntary request of the laboratory to be visited.

This was announced at the recent meeting of ASTM Committee C-1 on Cement pursuant to action taken by the Subcommittee on the Cement Reference Laboratory.

The addition of concrete laboratory inspection increases very materially the cost of operation of CRL; likewise the inspection of cement laboratories has increased greatly in cost in recent years as a result of mounting costs of travel, salaries of technical personnel, scientific equipment, etc. The ASTM Subcommittee on CRL, therefore, has found it necessary to announce that henceforth a schedule of nominal fees will be charged to each laboratory inspected. These charges will be as follows:

Inspection of cement testing laboratory	$100
Inspection of a concrete testing laboratory	$100
Inspection of a laboratory testing both cement and concrete	$150

These charges will begin March 1, 1958. Collection of the fees thus received will be under the jurisdiction of the American Society for Testing Materials. The average actual cost of individual inspection of a laboratory is several times greater than the amount of the fees established in accordance with the above schedule. This is true even though a considerable part of the paper and committee work connected with CRL operations is absorbed at no charge by one or more of the supporting agencies.

Impetus for the above moves with respect to CRL operations grew, in part, from demands arising from the general growth of the concrete construction industry in the postwar years and particularly from the agencies concerned with the new National Interstate System of Highways.

J. R. Dise continues as head of the Cement Reference Laboratory, and questions concerning its operations may be addressed to him at the National Bureau of Standards, Washington 25, D. C. or to A. Allan Bates, Chairman of the Cement Reference Laboratory Subcommittee of ASTM, c/o Portland Cement Assn., 33 West Grand Ave., Chicago 10, Ill.

ASTM Participates in 1958 Nuclear Congress

THE 4th Nuclear Engineering and Science Conference will be a major part of the Nuclear Congress to be held at the International Amphitheater in Chicago, March 17–21. The Conference is sponsored by the American Nuclear Society jointly with about 30 other technical societies, including ASTM. ASTM is sponsoring three of the more than 200 papers:

Density Measurements of Saturated Submersed Sediment by Gamma Ray Scattering—Lloyd O. Timblin, Jr.

High Temperature Fatigue Testing—with Applications to Uranium—Jack R. Bohn and Glenn Murphy

Inspection and Testing of Pressure Piping as Related to Nuclear Power Plants—V. T. Malcolm and Sidney Low (sponsored jointly with ASME)

The Congress is being coordinated by the Engineers Joint Council and in addition to the Conference mentioned above includes the Atomic Energy Management Conference sponsored by the Atomic Industrial Forum and the National Industrial Conference Board; the 6th Hot Laboratories and Equipment Conference, sponsored by the Hot Laboratories Committee; and the AtomFair, an exhibit sponsored by the Atomic Industrial Forum.

Preprints of papers will be available in advance from the American Institute of Chemical Engineers at 50 cents each. Complete lists will accompany an advance program which will be available from the secretaries of the participating societies or from the Secretary of the Engineers Joint Council, 29 West 39th St., New York 18, N. Y.

Chicago District Luncheon

In connection with the Congress, the Chicago District of ASTM is sponsoring a luncheon on Wednesday, March 19, in the Harvest Room of the Stock Yards Inn. Society members attending the conference are urged to attend. Tickets will be $4 each and may be purchased in advance from Society Headquarters or from C. S. Macnair, consultant, Consumer Products Division, Acme Steel Co., (135th St. and Perry Ave.) Chicago 27, Ill.

OTS Research Reports

These reports, recently made available to the public, can be obtained from the Office of Technical Services, Department of Commerce, Washington 25, D. C. Order by number.

Evaluation of the Engineering Properties of Titanium Carbide Base Cermets. PB 131026.

The Effect of Elevated Temperature on the Fatigue Strength of Sintered-Aluminum Powder. 131225

Protective Shot Peening of Propellers: Part 3—Fatigue and Distortion. PB 131273.

Heat Resistant Dibutyl Titanate Paints for Rocket Launchers. PB 131268.

Antiozonants for Nitrile and Natural Rubbers. PB 131267.

Fluorine-Containing Polyethers: Part 2. PB 131227.

Investigation of the Applicability of High-Frequency Sound Waves (Ultrasonics) for Cleaning of Precision Parts. PB 131361.

Development of a Nondestructive Test for Evaluation of Adhesion of Electrodeposits on Steel as in Silver-Plated Aircraft Bearings. PB 131226.

Stainless Steel and Titanium Sandwich Structures. PB 121633.

The Physical Properties of Titanium and Titanium Alloys. PB 121629.

Porosity in Formed Titanium. PB 121628.

High-Temperature Brittleness in Titanium Alloys. PB 131381.

A half century of work in corrosion of iron and steel

Committee A-5 Celebrates Fiftieth Anniversary

In commemoration of the fiftieth anniversary of one of the Society's oldest committees, H. F. Hormann, First Vice-Chairman of Committee A-5 on Corrosion of Iron and Steel, here recounts the high points of the committee's history. He was particularly fortunate in being able to consult F. N. Speller, a charter member of the committee. He also wishes to acknowledge the help of R. F. Passano, a longtime member of the committee, who was able to supply information not found in published reports. The author also wishes to thank the many committee members who assisted with constructive criticism for this article.

A. S. Cushman, first chairman of Committee A-5 (1907–1914).

More than fifty years ago a controversy existed as to the relative merits of iron and steel in resisting atmospheric corrosion. Shortly before the turn of the century, the decreasing use of wrought iron and the increasing use of steel resulted in the construction of certain structures, notably railroad signal bridges, in which the indiscriminate use of wrought iron and steel was permitted. This practice afforded an opportunity for making a direct comparison of sorts between these two materials. It was not uncommon at the time to find lateral bracing angles which crossed one another to be corroding at greatly different rates. Examination of fractured specimens disclosed that one was wrought iron and the other was steel.

During the Ninth Annual Meeting of ASTM held in June, 1906, Edgar Marburg, Secretary-Treasurer of the Society, after listening to papers and discussions on the corrosion of iron and steel made the following motion: "In view of the importance of this subject and the lack of knowledge concerning the same, it would seem to be eminently proper for the Society to appoint a standing committee on the general subject of the corrosion of iron and steel. I move that the Executive Committee be requested to consider the desirability of appointing such a committee." This motion was carried and by the time of the 1907 Annual Meeting the Committee U, on Corrosion of Iron and Steel, had been formed under the chairmanship of A. S. Cushman and the secretaryship of W. H. Walker, with a membership of ten. In 1910 the designation was changed to A-5.

One of the characteristics of active Committee A-5 members in early days (most all were active—some more than others), was their earnest adherence to traditional ideas regarding corrosion of iron. This led to what later became a curious inconsistency. The most popular idea, before the electrochemical theory was proved and generally accepted, was that the corrosion tendency was inherently stronger in some of the common commercial ferrous metals than in others. Comparative data were lacking and the effect of differences in environment was not generally recognized as an important factor, so those who pinned their faith in well-made low-carbon steel had to defend themselves against the claims of wrought iron (a relatively impure iron) on one hand, and ingot iron (a very pure type of open-hearth steel) on the other. This led to near fist encounters on the floor by well-meaning partisans.

Wrought iron, being the oldest form of commercial wrought ferrous metal, seemed to have, the advantage of argument for a time, but this was founded on traditional reports rather than satisfactory evidence. W. H. Walker, one of the great pioneers in corrosion study, quieted an argument at one committee session by referring to Pliny's report on failure of an early Roman bridge wrought iron chain as being due to the deterioration of the art, whereas it was probably due to climatic differences.

Differences of opinion concerning the variation in corrosion rates of iron and steel caused heated debates and, even further, caused at least one lawsuit to be started. By the time the committee was formed, the tonnage of wrought iron products had fallen to about 10 per cent of the total iron and steel production, about half of the steel products being made by the bessemer process. In 1927, the tonnage of wrought iron products represented only 2 per cent of the total and less than 15 per cent of the steel products were made by the bessemer process. The advocates of wrought iron had expended much time and energy in solving the problems presented by the manufacture of open-hearth iron.

Among the reasons suggested in the papers and discussions at the 1906 Annual Meeting of the Society for the difference in corrosion rates of iron and steel were: (1) too high manganese content in the steel, (2) too low phosphorus content in the steel, (3) protection afforded to the iron by the slag content, (4) changes in conditions, that is, an increase in electrolysis and an increase of sulfurous acid in the atmosphere, (5) a difference in cementite

(Fe_3C) content, and (6) failure to continue tests to destruction.

As the early work of the committee involved trying to find out why there was a difference in the corrosion rates of wrought iron and steel, one of the first things attempted was to establish a quick test permitting conclusions to be drawn as to the natural corrosion rate. As sulfur dioxide was thought to be one of the major causes of corrosion, it was natural for the committee to decide to investigate any correlation between resistance to acid and resistance to atmospheric corrosion. One of the tests then in use was to immerse the specimens in 20 per cent sulfuric acid for a specified time and then to measure the weight loss. It was concluded from these tests that observed differences in resistance to the acid test did not furnish a basis for concluding that metal manufactured by one process was superior to that manufactured by another process.

As would be expected, the early work of the committee was concerned with field tests rather than the preparation of specifications. In 1908, the committee started its first test which was to determine: (1) effect of possible segregation in the ingot, (2) influence of high carbon and manganese *versus* low carbon and manganese, and (3) effect of increasing amounts of manganese on basic open-hearth steel.

To determine the effect of possible segregation in the ingot, billets were taken from the top, middle, and bottom of the first and last ingots of a six-ingot pour of bessemer steel. The heat had the following analysis: carbon—0.09, manganese—0.55, sulfur—0.045, phosphorus—0.092.

The billets were rolled into rods, cleaned and drawn into 12, 11, and 9 gage wire. The wire was then galvanized, wiped by a mechanical device, and six pieces of fencing each about 300 ft long were then woven representing the top, middle, and bottom of the first and last ingots of the heat.

To determine the influence of high carbon and manganese *versus* low carbon and manganese, a 9 gage wire was drawn from basic open-hearth steel which contained 0.66 per cent carbon and 0.84 per cent manganese. The process of galvanizing was carried out in exactly the same way as for the wire which was manufactured to investigate the possible effect of segregation, except that the wire was not wiped, that is, it was allowed to retain as much zinc as would adhere to it. For a low-carbon and low-manganese wire, comparison was to be made with the appropriate wire in the third group which was manufactured to investigate the effect of increasing amounts of manganese on basic open-hearth steel. For this third group of wires, the manganese content ranged between 0.07 and 0.37 per cent. The carbon content ranged between 0.04 and 0.06 per cent. The sulfur and phosphorus content was fairly uniform for the entire range of manganese.

The wires, or fences fabricated from them, were erected on the grounds of the Carnegie Technical Schools in Pittsburgh, Pa., between September 23 and 26, 1908. In 1911 the committee reported no difference in the extent of corrosion suffered by the different panels made of steel selected from different parts of a bessemer heat or different parts of bessemer ingots from a heat. They also reported no failures of the coatings of the wires which were made to test the longevity of galvanized wires of different chemical compositions. Unfortunately, interest in the work of the committee seemed to diminish between 1911 and 1915. The committee was reorganized in 1915 and no further mention is made of these tests in committee reports after 1911.

In 1908, the committee also conducted laboratory tests on about 50 pigments as protective coatings for steel. Steel samples were hung in water suspensions of the various pigments and air was blown through the containers for definite periods of time, the corrosion being measured by the loss in weight sustained by the test specimens. As a result of the laboratory tests of the pigments, the committee decided to make a systematic investigation of the same pigments under field conditions. With the cooperation of the Paint Manufacturer's Assn, a series of steel panels painted with the same pigments as were used for the laboratory tests were erected in the autumn of 1908 in Atlantic City, N. J., and were inspected for the first time in April, 1910. These paint tests were conducted jointly with ASTM Committee D-1 on Paint, Varnish, Lacquer and Related Products.

During the period from 1910 to 1911 work was done by the committee on various methods for determining the weight of zinc coatings on iron and steel. One of the tests in vogue at the time was the Preece test, in which the zinc coating is dissolved in a copper sulfate solution of specified strength by immersing the specimen for one-minute intervals and noting the number of dips required to deposit copper by displacement of the zinc. The merits of the Preece test in determining the thicknesses of zinc coatings have long been debated. It is interesting to note a portion of the 1911 annual report which stated, "It is however the unanimous opinion of the committee that the well-known Preece copper sulphate test is unreliable and should be abandoned entirely as a basis of specification with respect to sheet and plate." (Committee A-5 has recently voted to abolish the specification for the Preece test when its use in ASTM specifications has been discontinued.)

It was not until the summer of 1915 that anything of a definitive nature was done to investigate the corrosion of iron and steel. During the previous year five general meetings had been held and it had been determined to make a comprehensive test to determine the relative resistance of the various types of ferrous metals to atmospheric corrosion. The test consisted of two series. The first, series A, involved commercial bessemer steel, acid open-hearth steel, basic open-hearth steel, pure iron (made by the basic open-hearth process) and puddled iron, all obtained in the open market to chemical compositions which were stipulated by the committee for each product. The second, series B, had the same composition as the first series, except that the percentage of copper was increased to come within the range 0.15 to 0.30. The tests in both series were made on uncoated sheets approximately 36 by 96 in. in 16 and 22 gage. The sheets were exposed on the grounds of the Naval Academy at Annapolis, Md., in October, 1916; at Fort Pitt, Pittsburgh, Pa., in December, 1916; and at Fort Sheridan, Ill., in April, 1917.

A check of the chemical compositions of the sheets disclosed that they varied considerably from the compositions that had been specified by the committee, particularly in regard to copper content.

The tests at Pittsburgh were terminated March 9, 1923, and the committee rated the corrosion resistance of the 22 gage sheets in that environment as follows, the most corrosion-resistant being given first:

1. Copper-bearing bessemer steel
2. Copper-bearing acid open-hearth steel
3. Copper-bearing basic open-hearth steel
4. Copper-bearing pure iron
5. Copper-bearing wrought iron
6. Low-copper wrought iron
7. Low-copper pure iron
8. Low-copper basic open-hearth steel
9. Low-copper bessemer steel

In 1928 an expansion program of the Government caused the abandonment of the Fort Sheridan uncoated sheet tests. Although corrosion of the specimens had not progressed as far as those on exposure at Pittsburgh, it had gone far enough for the committee to say that, generally speaking, the corrosion patterns at Pittsburgh and Fort Sheridan were the same.

Corrugated roofing sheets placed at Fort Pitt Arsenal, Pittsburgh, Pa., on December 12, 1916. Photograph, taken October 12, 1920, shows disintegration of the low-copper bessemer steel sheets.

In 1954 when the last inspection was made at Annapolis, in order to release the test site to the Navy, only 23 of the 16-gage sheets, out of a total of 258, had failed after 37.5 years of exposure. All the 22-gage sheets had failed, the time to failure ranging from a minimum of 7 years to a maximum of 34.5 years. The order of merit, determined from the failures of all sheets was very little different from the order as estimated from the failures after 9 years at Pittsburgh; given above.

In 1916 the committee decided to make a study of the methods which were being used for determining the amount of zinc coating on sheets and wire. Two methods were investigated, the basic lead acetate and the hydrochloric acid–antimony chloride methods. A third method, the Preece test was not investigated since Committee A-5 had previously gone on record opposing its use for determining the amount of zinc coating. It was found, however, through the circulation of a questionnaire that the Preece test was widely used and stoutly defended in the determination of the amount of zinc on wires. As a result of the tests which were conducted, the committee recommended both the basic lead acetate and hydrochloric acid–antimony chloride methods. It was found that the accuracy of the method of testing, which is limited by differences due to variations in sampling, variations in the thickness of the coating across the sheet, errors due to the personal equation, etc., amounted to from 6 to 8 per cent of the amount of zinc as determined by weighing individual sheets before and after coating.

Sometime between the 1919 and 1920 Annual Meetings, Committee A-5 decided that it would be desirable to determine the corrosion resistance to running water of the uncoated sheets which had been put out for atmospheric corrosion tests at Pittsburgh, Fort Sheridan, and Annapolis. As portions of the atmospheric exposure sheets had previously been cut off and had been stored at the National Bureau of Standards, Washington, D. C., opportunity presented itself to conduct these immersion tests. Test specimens were accordingly arranged in boxes so that the specimens were completely immersed and the flow was adjusted to a rate of approximately 6 gal per min through a box which had a volume of 96 gal so that there was an average change of water every 16 min. Specimens were exposed at the Bureau of Standards, to the action of city water, at the Engineering Experiment Station, U. S. Naval Academy, Annapolis, Md., for the effect of the brackish water of Chesapeake Bay, and in a mine near Pittsburgh for the effect of the drainage water from a coal mine. The results of these immersion tests caused the committee to conclude that copper had no beneficial effect in decreasing the corrosion rate in water. In fact, if it had any effect, it seemed to be slightly detrimental. The median life of the sheets exposed to the mine water was 46 days for the 22 gage sheets and 113 days for the 16 gage sheets. Based upon the lighter gage sheets those exposed to the brackish water of the Severn River showed approximately 40 per cent longer life than those exposed to Washington, D. C., city water, and about 26 times longer life than the sheets immersed in the mine water. These immersion tests were later extended to provide for immersion in ocean water at Portsmouth, N. H., and Key West, Fla. At Portsmouth the minimum and maximum number of days to failure for the 22-gage sheets were 654 and 1226, and at Key West were 605 and 1459. For the 16-gage sheets at Portsmouth the corresponding times were 1749 and 3069, and for Key West, 1630 and 3886. The subcommittee responsible for these tests came to some very general conclusions with regard to the results of the tests at Portsmouth and Key West. One of them was that copper had a beneficial effect from the corrosion point of view in the 16-gage sheets for all the materials tested, except the high phosphorus steels. The effect of copper in the 22-gage sheets was less significant. This finding, concerning the effect of copper in the Portsmouth and Key West tests, contradicts the observations which were made in connection with the tests at Washington, Chesapeake Bay, and the mine at Pittsburgh.

The year 1923 was marked by the fact that the committee made its first recommendation to the Society—two methods of test for publication as tentative. Since that time the committee has sponsored 22 specifications and 9 methods of test, as well as 3 emergency specifications during the war.

In 1924 it was decided to start a new series of tests involving the atmospheric exposure of bare and galvanized sheets and wire of the same steel with different coating weights, and hardware with a variety of coatings. These tests are continuing but are reduced in scope because of failures and losses of specimens, or because the sites were needed for other use. The sheet tests got under way soon after the erection of test racks, at State College, Pa., in October, 1925, at Altoona, Pa., in November, 1925, at Brunot Island, Pittsburgh, Pa., in December, 1925, at Key West, Fla., in February, 1926, and at Sandy Hook, N. J., in March, 1926.

In connection with the sheet tests, it is interesting to compare the relative corrosion rates of zinc-coated sheets with uncoated sheets with respect to location. In the tabulation which follows, the location at which the corrosion rate was highest is given first. For the zinc-coated sheets the order is based upon the time to first rust. For the uncoated sheets the order is based upon the time to the first perforation.

Zinc-Coated Sheets	Uncoated Sheets
Altoona, Pa.	Key West
Brunot Island, Pittsburgh, Pa.	Brunot Island
Sandy Hook, N. J.	Sandy Hook
State College, Pa.	Altoona
Key West, Fla.	State College

A peculiarity of the corrosion of the galvanized sheets at Key West was that the corrosion took place on the underside. This peculiarity has been reported for galvanized sheets making up the roofs of buildings in other parts of Florida, the Canal Zone, and the Philippines.

The hardware specimens were placed on exposure in December, 1928, and January, 1929, at the same locations at which the sheets were exposed. Of the five sites at which specimens were exposed, only the State College site remains.

The wire tests did not get under way until the latter part of 1936 and early part of 1937. These tests included farm fence, barbed wire, wire strand, chain link fence, and unfabricated wires of various compositions. These wire specimens were coated with zinc, copper, or lead, or were corrosion resistant in themselves. They were exposed at eleven locations throughout the United States.

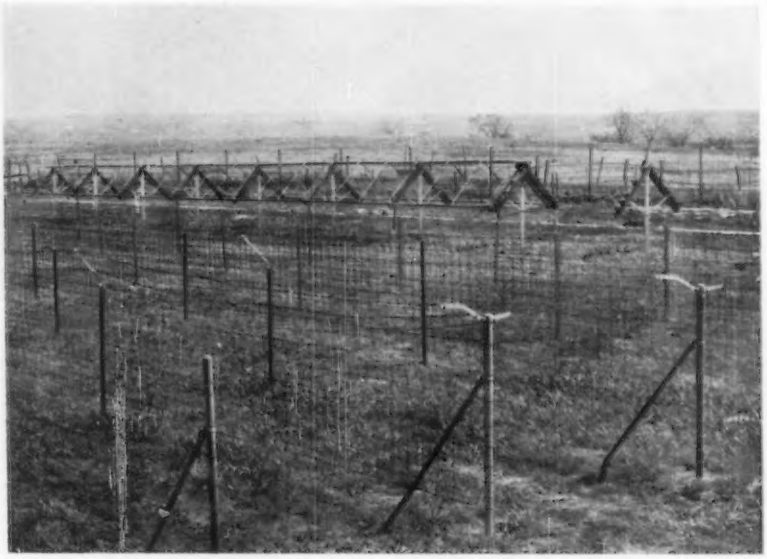
Four of the locations were the same as for the sheet and hardware tests, the exception being Altoona, Pa., and in addition there were the following seven locations: Lafayette, Ind., Ithaca, N. Y., Ames, Iowa, College Station, Tex., Manhattan, Kans., Davis and Santa Cruz, Calif.

Fifteen years after the start of the exposure tests on these wires, a comparative study of the corrosion rates at seven of the sites was prepared. Based solely upon the performance of the zinc-coated wires these rates were found to be as follows:

Pittsburgh, Pa.	0.34 oz
Sandy Hook, N. J.	0.13 oz
Bridgeport, Conn.	0.13 oz
State College, Pa.	0.06 oz
Lafayette, Ind.	0.07 oz
Ithaca, N. Y.	0.06 oz
Ames, Iowa	0.04 oz

The above figures represent the losses of weight of zinc per year in ounces per square foot, the time to first rust being taken as the time to failure, on the premise that once rusting of the steel has started the time thereafter to complete failure of the coating will be short. By this criterion it is evident that 1 oz per sq ft of zinc on an article exposed in Pittsburgh would show rust at the end of 3 years whereas it would take 25 years for a similar article to show first rust if exposed in Ames, Iowa.

The committee was also interested in several other tests, one of which was a riveted plate test requested by Lloyd's Register of Shipping. The object of this test was to investigate the corrosion of high- and low-copper steel plates, and silicon-steel plates fastened together with rivets of different composition, when exposed to sea water. Plates were submerged in the waters at Portsmouth, N. H., Key West, Fla., and Port Arthur, Tex., in 1926. As a means of recording the degree of corrosion, copper replicas of the plates were made at the time of inspection. Several of these were exhibited at the 1937 Annual Meeting. In 1932 it was reported that the rivets showed spongy corrosion and pitting about equally divided among the rivets, with all caulked rows in better condition than the rows of rivets which had not been caulked. As time went on, the inspections became more sporadic and finally stopped altogether with the loss of the specimens. A test which was never started was designed to investigate the corrosion of metal culverts of 14-gage steel with a 2-oz zinc coating when installed in the field under roads and railroads and subjected to an intermittent water flow. Some 40 state highway departments and 50 railroads evinced an interest in these tests, but the advent of the depression in the 1930's and the magnitude of the test caused it to be abandoned.



Farm fencing and unfabricated wire erected at Kansas State College, Manhattan, Kans., on December 4, 1936. Photograph taken in May, 1956, following almost 20 years of exposure.

A rather noteworthy undertaking which was carried through to completion was an investigation of the causes of embrittlement of hot-galvanized steel. This subject was investigated as a joint venture of the Utilities Research Commission of Chicago and Subcommittee X on Embrittlement Investigation, of Committee A-5. The work was done at Battelle Memorial Institute and was described in a paper titled "Embrittlement of Hot-Galvanized Structural Steel" by Samuel Epstein, and appears in ASTM *Proceedings*, Vol. 32, Part II, p. 293 (1932).

The many papers contributed by Committee A-5 members are too voluminous to be commemorated here. It is sufficient to say that beginning with Allerton S. Cushman's, "The Corrosion of Iron," ASTM *Proceedings*, Vol. 7, p. 211 (1907), many important papers have been published.

Presently, the committee is continuing to study the revision of existing specifications, methods of test, and practices. It has also embarked on a new test which has reached the stage where specimens are being prepared. This test will determine the effects of atmospheric corrosion on carbon steel, four low-alloy steels, and two nodular irons in the bare condition and when protected with hot-dipped zinc, hot-dipped aluminum, electroplated zinc, sprayed zinc, and sprayed aluminum. Exposure sites for this test are Newark, N. J., and the 80-ft and 800-ft lots at Kure Beach, N. C.

Since its inception, Committee A-5 has had eight chairmen and eight secretaries. The ninth and present holders of these offices are Marc Darrin of Allied Chemical and Dye Corp., and C. P. Larrabee of the U. S. Steel Co., respectively.

Aerial view of the Engineering Test Reactor buildings at the National Testing Station, Idaho.

Industrial Progress in Nuclear Field During 1957

THE Atomic Industrial Forum in January, 1958 published "The Atomic Industry—1957," its annual progress report on developments in commercial applications of atomic energy during the past year.

The detailed report shows that during 1957 the U. S. atomic industry completed the construction of 16 nuclear reactors, including 7 power-type reactors and 9 research and test reactors, for both private and governmental purchasers in the U. S. and abroad. The power-type reactors include those designed for naval ship propulsion and for prototype and demonstration power plants. In addition to these projects, industry continued or began the construction of 59 reactors, 35 of which are power-type reactors and 24 of which are research and test reactors, and received orders for the manufacture of 10 new reactors—5 for the production of electric power and 5 for research and test purposes.

Also in the past year, 13 companies announced plans to enter the field of nuclear fuel element production and research, one company began construction of a privately owned feed materials plant, three companies completed construction of plants for the production of zirconium, and two companies completed construction of plants for the production of beryllium.

U. S. Power Reactors

Completed.—During the year the U. S. atomic industry completed the construction of four domestic nuclear power and power-experiment reactors. One was built by an industrial concern for its own account and the other three were built by industry for the AEC. In addition, during the year two AEC laboratories completed three experimental power-producing facilities at Government sites.

The General Electric Co. completed a 5000-ekw boiling water reactor at Vallecitos, Calif. for its own use. (All figures referring to electrical power output are expressed in terms of kilowatts of gross capacity (ekw). Alco Products, Inc. completed a 2000-ekw pressurized water package power reactor for the AEC and the U. S. Army at Fort Belvoir, Va. and North American Aviation, Inc. completed two reactors for the AEC—a 6500-ekw sodium reactor experiment at Santa Susana, Calif., and an organic moderated reactor experiment at Arco, Idaho, which produces 16,000 kw of heat but no electricity.

Westinghouse Electric Corp. completed a 68,000-ekw pressurized water reactor for the AEC at Shippingport, Pa.

The Government-built plants are a 5000-ekw experimental boiling water reactor built at Lemont, Ill., by the Argonne National Laboratory, a 300-ekw homogeneous reactor experiment built at Oak Ridge, Tenn., by the Oak Ridge National Laboratory, and a 200-ekw experimental breeder reactor at Arco, Idaho, first operated in 1951 and newly rebuilt by Argonne National Laboratory.

Under Construction.—Four industrial organizations during the year continued or began the manufacture of U. S. power producing reactors being built by an AEC laboratory:

Babcock & Wilcox Co.—A 163,000-ekw (nuclear) pressurized water reactor with a conventionally fired superheater which will supply an additional 112,000 ekw, for Consolidated Edison Co. of New York at Indian Point, N. Y., scheduled for completion in 1960.

General Electric Co.—A 180,000-ekw boiling water reactor for Commonwealth Edison Co. of Chicago at Dresden, Ill., scheduled for completion in 1960.

Power Reactor Development Co.—A 100,000-ekw fast reactor at Monroe, Mich., scheduled for completion in 1960.

Westinghouse Electric Corp.—A 134,000-ekw pressurized water reactor for the Yankee Atomic Electric Co. at Rowe, Mass., scheduled for completion in 1960.

The Government-owned reactors, both of which were being built by the Argonne National Laboratory at Arco, Idaho, were a 20,000-ekw experimental breeder reactor scheduled for completion in 1959, and a 200-ekw boiling water package power reactor scheduled for completion in 1958.

New Contracts.—Two industrial firms received contracts during 1957 to manufacture power reactor plants which will involve AEC financial assistance—of which one will be owned by a private organization and the other will be owned by the AEC and operated by a local governmental organization. In addition, one industrial firm received a contract for the manufacture of a reactor for which AEC financial assistance had been requested but not yet granted.

Allis-Chalmers Manufacturing Co.—A 66,000-ekw boiling water reactor plant (of which about 53,000 ekw will be nuclear, the rest produced by a conventional superheater) to be built for Northern States Power Co. and ten associated utility companies at Sioux Falls, S.D., scheduled for completion in 1962. The project has received an AEC assistance contract.

North American Aviation, Inc.—a 75,000-ekw sodium graphite reactor to be built for AEC for operation by the Consumers Public Power District, at Hallam, Nebr., scheduled for completion in 1961.

Westinghouse Electric Corp.—A 17,000-ekw heavy water reactor to be built for Carolinas Virginia Nuclear Power Associates, Inc. at Parr, S. C., scheduled for completion in 1962. The project has applied for, but has not yet received, an AEC assistance contract.

In addition to these, the Florida Nuclear Power Group also applied for, but at the end of the year had not received, an AEC assistance contract for the construction in central Florida of a 136,000-ekw natural uranium, gas cooled, heavy water moderated power reactor to be designed by General Nuclear Engineering Corp. A manufacturer has not been named.

By the end of 1957 a total of seven power reactor plants not owned by the federal Government were in operation, under construction, or contracted for. These projects represent an estimated total investment of more than $280 million, and would have a capacity of more than 650,000 nuclear kilowatts of electricity. These figures do not include such Government-owned reactors as the 68,000-ekw pressurized water reactor at Shippingport, Pa., the 6500-ekw sodium reactor experiment at Santa Susana, Calif., or the 2000-ekw Army package power reactor at Fort Belvoir, Va. The figures also do not include the 75,000-ekw sodium graphite reactor to be built at Hallam, Nebr., which AEC will own but which will be operated by the Consumers Public Power District.

"It is a common belief that atomic power development is primarily the province of the nuclear physicist. Nothing could be farther from the truth. The main problem is with materials and equipment generally considered as conventional—but which must conform to the exacting standards required of all components of a nuclear power plant"—*Rear Admiral H. G. Rickover, Chief, Naval Reactors Branch, Division of Reactor Development, U. S. Atomic Energy Commission*—quoted in *Steelways*

U. S. Propulsion Reactors

Merchant Ships.—The Babcock & Wilcox Co. received an AEC contract during 1957 for the manufacture of a 74,000-kw (heat) pressurized water reactor for the propulsion of the N. S. Savannah, the U. S.'s first merchant ship, which is scheduled for completion in 1960.

Navy.—During the year two nuclear powered submarines built by industry for the U. S. Navy began operation, one new project for the development of nuclear propulsion for naval surface vessels was awarded to an industrial company, and three companies continued the manufacture of 28 reactors for naval ship propulsion under previously awarded contracts. The two firms which manufactured the propulsion reactors for submarines coming into operation in 1957 were the following:

General Electric Co.—The sodium-cooled intermediate neutron reactor in the submarine Seawolf.

Westinghouse Electric Corp.—The pressurized-water reactor in the submarine *Skate*.

The General Electric Co was assigned a new development project by AEC for a pressurized water reactor for destroyer and frigate propulsion.

Companies continuing previously awarded projects for the development and manufacture of naval reactors are:

Combustion Engineering, Inc.—A land-based prototype pressurized-water reactor to power a small attack submarine, and for the manufacture of the reactor to propel the actual submarine.

General Electric Co.—A land-based prototype pressurized-water reactor to power a radar picket submarine, and for the manufacture of the two reactors which will propel the submarine itself.

Westinghouse Electric Corp.—A two-reactor land-based prototype pressurized-water power plant for use in cruisers and aircraft carriers, for the manufacture of two reactors to propel the U. S.'s first nuclear powered cruiser, for the manufacture of eight reactors to propel the U. S.'s first nuclear powered aircraft carrier, and for the manufacture of pressurized-water reactors to propel eleven submarines.

Aircraft.—General Electric Co. and Pratt & Whitney Aircraft continued work on the development of reactors for the propulsion of military aircraft, under AEC contract. Information concerning the development of nuclear powered aircraft is almost completely classified.

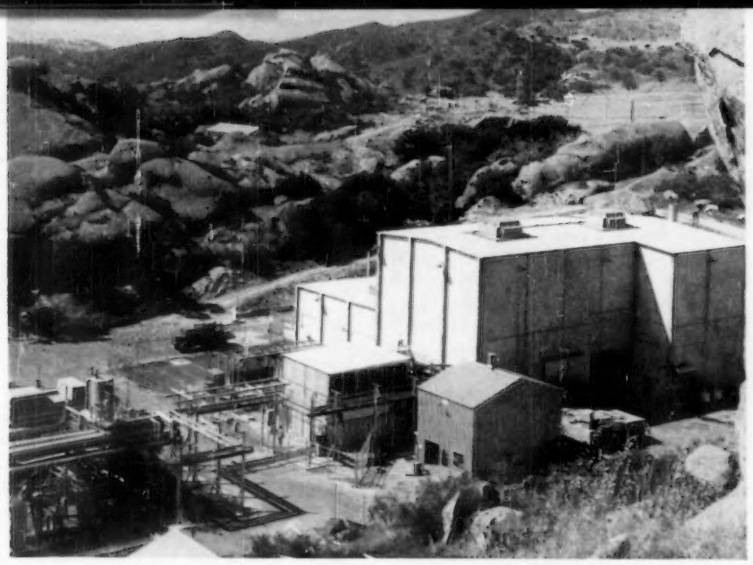
U. S. Power Reactors Sold Abroad

During the year Westinghouse began the manufacture of an 11,500-ekw pressurized-water reactor for the Belgian governmental Centre d'Études pour les Applications de l'Energie Nucléaire and a group of industrial firms at Mol, Belgium.

Westinghouse also received a letter of intent for a 134,000-ekw pressurized-water reactor to be constructed near Milan, Italy for the Societa Elettronucleare Italiana (SELNI).

Vitro Corp. of America received a contract covering architect-engineering and supervisory services for a 150,000-ekw pressurized-water reactor to be built in southern Italy for the Societa Italiana Meridionale Energia Atomic (SIMEA).

These were in addition to plans announced in 1956 by American & Foreign Power Co. to build three 10,000 to 12,000-ekw reactors, located in the systems of A&FP subsidiaries in Brazil, Cuba, and Mexico—two of which would be boiling water reactors manufactured by General Electric Co. and one of which would be an organic moderated reactor manufactured by North American Aviation, Inc.—and to plans an-



Sodium Reactor Experiment. Heat produced by this reactor is used by the Southern California Edison Co. to generate electricity.

nounced by the Martin Co. to manufacture a 13,000-ekw pressurized-water reactor for the Dominican Republic. These plans are contingent upon the negotiation of bilateral agreements covering power reactors between the U. S. and the respective countries involved or the satisfactory negotiation of indemnity and other provisions.

U. S. Research Reactors

Privately Owned—During 1957, the Babcock & Wilcox Co. completed a 1000-tkw pool type reactor for the University of Michigan.

Companies with research reactors under construction were:

ACF Industries, Inc.—a 5000-tkw heavy water reactor for the Massachusetts Institute of Technology.

American Machine & Foundry Co.—a 5000-tkw pool type reactor for Industrial Reactor Laboratories, Inc., and a 5000-tkw pool type reactor for Union Carbide Nuclear Co.

Curtiss-Wright Corp.—a 1000-tkw pool type reactor for its own use.

Westinghouse Electric Corp.—A 20,000-tkw tank type test reactor for its own use.

Companies with new contracts for research reactor construction were:

General Electric Co.—A 30,000-tkw pool type test reactor for its own use.

Nucledyne Corp. (subsidiary of Cook Electric Co.)—A 100-tkw pool type reactor for North Carolina State College.

These are in addition to reactors completed in previous years for private U. S. buyers by the following industrial concerns:

American Machine & Foundry Co.—A 1000-tkw pool type reactor for Battelle Memorial Inst.

North American Aviation, Inc.—A 50-tkw solution type reactor for Armour Research Foundation.

During the year Georgia Institute of Technology also announced plans to build a heavy water research reactor designed by General Nuclear Engineering Corp. The University of Virginia received an AEC construction permit for a 1000-tkw pool type reactor.

Previously awarded research reactor contracts from U. S. buyers other than the U. S. Government, under which construction has not yet begun, include the following: American Machine & Foundry Co. for a pool type reactor for the University of Buffalo; General Electric Co. for a pool type reactor for the State College of Washington; and North American Aviation, Inc. for a solution type medical research reactor for the University of California at Los Angeles.

Government Owned—During the year Foster Wheeler Corp. completed a 1000-tkw pool type reactor at Livermore, Calif.; and Kaiser Engineers and General Electric Co. completed a 175,000-tkw tank type engineering test reactor at Arco, Idaho.

Companies manufacturing reactors for the Government are:

ACF Industries, Inc.—A pool type test reactor for the Air Force's Wright Air Development Center.

Daystrom, Inc.—A medical research reactor for Brookhaven National Laboratory.

General Electric Co.—A pool type test reactor for Lockheed Aircraft Corp., for work under Air Force contract.

North American Aviation, Inc.—A power excursion test reactor for the AEC.

Phillips Petroleum Co.—Two power excursion test reactors for the AEC.

U. S. Research Reactors Abroad

During 1957 these companies completed foreign research reactors:

American Machine & Foundry Co.—A 1000-tkw pool type reactor in Munich, West Germany, and a 10-tkw pool type reactor in Amsterdam, in the Netherlands.

Babcock & Wilcox Co.—A 5000-tkw pool type reactor for the University of Sao Paulo in Brazil.

General Dynamics Corp.—The Canadian subsidiary completed a low power pool type reactor for Atomic Energy of Canada, Ltd. at Chalk River, Canada.

North American Aviation, Inc.—Two 50-tkw solution type reactors for the Japan Atomic Energy Research Institute at Tokai, Japan and for Farbwerke Hoechst, A. G., of Frankfurt, West Germany.

These U. S. firms exported components for overseas reactors:

ACF Industries, Inc.—A 30,000-tkw tank type reactor sold to the Swedish Atomic Energy Co. at Studsvik, Sweden; a 20,000-tkw tank type reactor sold to the Reactor Centrum Nederland at Petten, the Netherlands; and a 5000-tkw heavy water reactor sold to the Comitato Nazionale per le Ricerche Nucleare at Ispra, Italy.

American Machine & Foundry Co.—A 10,000-tkw heavy water tank type reactor sold to the Japan Atomic Energy Research Institute in Tokai, Japan; 1000-tkw pool type reactors, one each sold to the Societa Ricerche Impianti Nucleari of Milan, Italy; to the Greek Atomic Energy Commission of Athens, Greece; to the Portuguese Atomic Energy Commission of Lisbon, Portugal; and to Hamilton College of McMaster University in Hamilton, Ontario, Canada.

Babcock & Wilcox Co.—A 5000-tkw pool type reactor sold to the Society for the Utilization of Nuclear Energy in Shipbuilding & Navigation, Inc. at Hamburg, West Germany.

Foster Wheeler Corp.—A 5000-tkw tank type reactor sold to the Danish AEC at Risø, Denmark.

General Electric Co.—A 3000-tkw pool type reactor sold to the Instituto Venezolano de Neurologia e Investigaciones Cerebrales of Caracas, Venezuela, and a 3000-tkw pool type reactor sold to the Junta de Energia Nuclear at Madrid, Spain.

North American Aviation, Inc.—A 50-tkw solution type reactor sold to the Senate of West Berlin, Germany.

These U. S. firms received new research reactor contracts from abroad:

American Machine & Foundry Co.—A 1000-tkw pool type reactor for the government of Israel.

General Electric Co.—A pool type reactor for the government of Argentina.

North American Aviation, Inc.—A 50-tkw solution type reactor for the Politecnico of Milan, Italy.

Nuclear Development Corp. of America also continued under a previously awarded contract the design of a 25,000-tkw test reactor for Belgium.

Nuclear Fuels

Feed Materials.—Allied Chemical and Dye Corp. began construction under a previously awarded AEC contract of a plant to produce 5000 tons per year of U_3O_8 equivalent in the form of uranium hexafluoride. The plant is scheduled for completion in 1959 and will be the U. S.'s first privately owned feed materials production plant.

Fuel Element Research, Production and Recovery.—During the year the following 13 U. S. companies announced plans to undertake the production of nuclear fuels or nuclear fuel research:

American Bearing Corp. (subsidiary of National Lead Co.)

Clevite Corp.
Davison Chemical Co.
General Dynamics Corp.
General Motors Corp.
Lockheed Aircraft Corp.
D. E. Makepeace & Co.
Minnesota Mining & Manufacturing Co. and its subsidiary American Lava Co.
National Carbon Co.
Nuclear Materials & Equipment Co.
Oregon Metallurgical Corp.
Penn-Texas Corp.
Spencer Chemical Co.

One industrial concern (Baker & Co.) announced plans to enter the uranium scrap recovery field.

Included among the industrial organizations which have previously announced plans to enter the fuel element research and production field are the following:

Aerojet-General Corp.
American Machine & Foundry Co.
Atomic Power Development Associates
Babcock & Wilcox Co.
Battelle Memorial Inst.
Combustion Engineering, Inc.
General Electric Co.
Mallinckrodt Chemical Works
Martin Co.
Metals & Controls Corp.
North American Aviation, Inc.
Norton Co.
Nuclear Development Corp. of America
Nuclear Metals, Inc.
Olin Mathieson Chemical Corp.
Stanford Research Inst.
Sylvania-Corning Nuclear Corp.
Westinghouse Electric Corp.

Reactor Materials

Zirconium.—Three companies (Carborundum Metals Co., Columbia-National Corp. and Mallory-Sharon Metals Corp.) completed plants which will produce an annual total of 2.2 million lb of reactor-grade (free of hafnium) zirconium for AEC under fixed-price, five-year contracts with AEC. Mallory-Sharon Metals Corp. (which is partly owned by National Distillers & Chemical Corp.) announced during the year that it was doubling the capacity of its plant, from 1 to 2 million lb per year, to meet industrial requirements.

The Carborundum Metals plant is located at Parkersburg, West Va. and has a capacity of 500,000 lb per year; the Columbia-National plant is located near Pensacola, Fla. and has a capacity of 700,000 lb per year; and the Mallory-Sharon plant is located at Ashtabula, Ohio.

Beryllium.—Beryllium Corp. and Brush Beryllium Co. completed the construction of new facilities in 1957 in which each will produce 500,000 lb of reactor grade beryllium over a five-year period under contract to AEC.

Controlled Thermonuclear Research

Five companies announced during the year that they were involved in research in the field of controlled thermonuclear reactors.

Allis-Chalmers Manufacturing Co. and Radio Corp. of America received contracts to design and fabricate large experimental devices which will comprise the Model C Stellarator research device which Princeton University is building for the AEC.

General Dynamics Corp. received a contract from the Texas Atomic Energy Research Foundation for a four-year jointly sponsored research program.

International Industrial Agreements

The following six U. S. industrial concerns announced during the year that they had entered licensing agreements or joint ventures in the atomic energy field with industrial companies in other nations:

Alco Products, Inc.—A reactor construction and sales venture with Humphreys & Glasgow, Ltd. and Daniel Adamson & Co. of England.

American Machine & Foundry Co.—A reactor construction and sales venture with Mitchell Engineering, Ltd. of England.

H. K. Ferguson Co.—A joint venture covering the design and construction of nuclear projects with John Laing & Son Ltd. of England.

Kaiser Engineers—A nuclear development agreement with C. Itoh & Co. Ltd. of Japan.

North American Aviation, Inc.—A licensing agreement with Allmanna Svenska Elektriska Aktiebolaget (ASEA) of Sweden.

Westinghouse Electric Corp.—Licensing agreements with Fiat of Italy, Mitsubishi of Japan, and Ateliers de Constructions Electriques de Charleroi of Belgium.

State Activities

During the year four states—Arkansas, Ohio, Tennessee, and Washington—established atomic energy coordinators, bringing the total of such states to nine (the previous five being Connecticut, Maine, Massachusetts, New Hampshire, and Rhode Island).

Connecticut and Massachusetts issued radiation codes, in addition to the following four states which had previously issued codes (California, New York, Pennsylvania, and Texas).

Atomic energy study groups or commissions were appointed or authorized in eight states (Alabama, Kentucky, Massachusetts, Minnesota, South Carolina, Tennessee, Virginia, and Washington). These were in addition to the eleven states previously establishing atomic energy groups (Arkansas, Connecticut, Florida, Georgia, Illinois, Michigan, New Jersey, New York, Ohio, Texas, and Wisconsin).

During 1957 state legislatures in five states—Connecticut, Illinois, North Dakota, South Dakota, and Wyoming—passed legislation requiring registration of radiation sources.

The year 1957 also saw the formation of a Regional Advisory Council on Nuclear Energy, consisting of representatives from 16 southern states. The Council is studying the feasibility of an interstate nuclear energy compact.

RILEM Symposium on the Observation of Structures

Laboratorio Nacional de Engenharia Civil Av. do Brasil, Lisboa, Portugal $10.50.

The Transactions of the RILEM Symposium on the Observation of Structures was held in October, 1955, in Lisbon at the Laboratorio Nacional de Engenharia Civil.

The 54 papers and discussions presented during the sessions dealt with: (1) description and characteristics of the instruments for the measurement of displacements, opening of joints, cracks, and rotations; and strains, stresses, forces, temperatures and moisture; (2) evaluation of the properties of the materials; (3) programs, descriptions and interpretation of results of observations of dams, bridges, and other structures.

Standardization from an Air Line Viewpoint*

By R. D. KELLY

Superintendent of Technical Development,
United Air Lines, Inc.

The swift progress of the air transportation industry quickly renders standards obsolete but there are many basic ones that are useful for long periods of time

In a rapidly progressing industry like air transportation, standards should be considered as stepping-stones upward along the route of progress, rather than as plateaus. Aeronautical technological progress is advancing so rapidly that many standards are in active use for only a limited period of time. To me this represents a reasonable and proper situation. Our industry must not become stymied by adhering to old methods, procedures, and materials.

This does not deny that there are many basic standards which do remain useful for long periods of time and which may be used by many industries. Often these are used in the air transportation industry just as well as a standard that has been developed specifically for that industry's needs. For example, many current automotive specifications for screw threads, bearings, gears, finishes, and materials find direct application to aircraft usage.

But in looking back over 30 years or so of progress in civil aviation, it is significant that the principal materials and structural designs for our aircraft and power plants have changed many times. Thirty years ago, wood, fabric, steel tubing, and cable were basic structural materials. Today we rely upon the newest of the new metals and their alloys; also, upon the latest nonmetallic synthetics, fiber glass, and the like. The rate of change of materials has certainly exceeded linear proportions during this period. Modes of fabrication and application are quite different from the methods employed 30 years ago.

The need for standards has proceeded at a similar accelerated pace. Progress with economy, efficiency, and coordination, and the achievement of compatibility of materials, parts, and systems would not have been possible without industry standards developed as needed and discarded when they have served their purpose.

Such standards, developed and released by professional engineering societies and associations, would not be possible without the willing and objective cooperation of every industry having need for them. In this cooperative effort, the viewpoints of professional engineers and technical experts, representing the various producer and user interests, are integrated and compromised into specifications which become useful tools, but which have no legal significance unless and until they are accepted by contracting parties as a part of their contractual agreements.

Some aspects of industry-developed standards have not always been clearly understood by the air lines. Perhaps we have not cooperated as much as we should in such programs. It is my intention to discuss some of these aspects.

Importance of Attitude in Standards Development

Standards cannot for long be "imposed" upon any group. They must be useful and valuable tools for every person or organization using them. Therefore, the attitude of the parties to any standards conference must be objective and progressive rather than defensive. While it is incumbent upon each committee member to set forth, strongly and clearly, the position of his particular interests and specialized experience, his intention should be to make a contribution for the general good rather than to exploit a given design or established practice or to defend a selfish advantage. In this way opportunities are provided for each to learn the most about the over-all problems and still provide an atmosphere conducive to objective compromise. It is the medium by which an integration of the needs of producer and consumer can best be served in the development of useful and realistic standards.

Much more comes out of a standards conference than specifications alone. It is a means of communication and education. In the heat of the arguments, many ideas are "tried for size." Some flourish and many perish. Those having value eventually find acceptance and are developed into specification elements. More often than not, the identity of the first individual suggesting a new or useful idea is lost in the prompt general acceptance of it. Some persons may find the lack of recognition in such circumstances very distasteful and discouraging, but eventually they will learn that the group is also just as willing to overlook and forget the source of other proposed ideas which, when exposed to the critical appraisal of the group, prove to have obvious faults and shortcomings.

Need for Increased Participation of Air Line Engineers

To me it is self-evident that the air line industry has not often taken the interest in standards development that it should. It is believed that a more positive interest in standards development by air line engineers could be most useful in preventing later problems. Their participation in standards committee work should provide an earlier anticipation of actual service and main-

* Presented at the ASTM-sponsored session held during the Eighth National Conference on Standards of the American Standards Assn. in San Francisco, Calif. in November, 1957.

tenance experiences which should help to develop better basic specifications. Few design engineers have the benefit of day-to-day operating problems.

Usually a new design is predicated on the most efficient and economic factory production and assembly of the unit, making use of standardized parts and materials, special tools, jigs, and fixtures. Within limits this is good, and often represents the best approach. But the product and its design and fabrication should also be subject to critical analysis from the standpoint of eventual service and usage. Maybe it will be better and more effective to design a new fitting or part or employ a new material or method, if a real improvement in application and utilization can thereby be achieved.

Specifically, in connection with this thought, it is important to call attention to the fact that air line shops spend a great many more man-hours on a particular piece of equipment than are involved in the initial manufacture of the item. In its normal life it will be installed and removed from the aircraft a great many times, often in difficult places. Then it must be transported to the shop where it will be tested, disassembled, inspected, repaired (and oftentimes modified), reassembled, tested, and stocked. And eventually it is reinstalled again in the airplane for further service. The following "life and overhaul experience" of some items in United Air Lines service will serve as good examples:

1. Some of the Pratt & Whitney R-1830 engines used in the DC-3's for almost 20 years, were completely overhauled as many as 35 times.

2. Some of the Pratt & Whitney R-2800 engines used in United's DC-6, DC-6B, and Convair 340 fleets, have been completely overhauled as many as 21 times to date.

3. Accessory equipment may make even more frequent trips to the shops. Pumps, governors, generators, and the like may make 60 trips to overhaul during their life. Records indicate as many as 150 such trips for communications equipment.

Since the theme of this meeting relates to cost reduction as a function of standardization, the above should clearly emphasize the need for considering the whole life experience of the part or unit. The following are examples in which the selection or development of new standards is important.

1. Fittings and attachments to permit quick and easy installations.

2. Concentration of mass to effect minimum expenditure of space.

3. Elimination of excess (nonworking) metal and materials.

4. Elimination of sharp corners, abrupt changes of section.

5. Disassembly and assembly features which are obvious and amenable to ordinary shop facilities.

6. Parts design to make incorrect assembly or reversed hookups impossible.

7. Avoidance of the possibility of building up successive clearances which prevent proper operation or require special and individual fitting and testing.

It may be said by some that these criteria relate more to good basic design than to standards, but I believe that there must be consistent coordinated efforts between design and using engineers to insure the development of safe, useful, and reliable equipment capable of remaining functional and economical throughout its entire life span. Thus, standardization becomes doubly important when this whole life picture is taken in perspective, and standardization meetings provide one of the most valuable opportunities for design and operating engineers to exchange views and experiences.

With respect to economy, the total cost of accomplishing the desired task must be an integration of all costs associated with the design, development, installation, operation, servicing, maintenance, overhaul, etc. divided by the total product produced or service rendered. This final unit cost, taken together with the quality of product, is the measure of merit by which the benefits of standardization should be judged. In such an evaluation, usually it will be found that not just one but many individual specifications and industry-accepted standards have contributed to the economy.

If this is so, then it clearly demonstrates the need for users, particularly safety, service, and reliability-conscious organizations such as air lines, to contribute their know-how and understanding of day-to-day problems to the groups charged with formulating standards. The experience of this group should be of significant value, too, in determining when a standard has served its purpose and needs replacement.

The above paragraph is written with the certain knowledge that air line engineers and technicians in large numbers are not likely to be clamoring for membership on standards committees, nor will their managements often be found urging their participation. Some of this stems from the fact that under the pressure of the daily chores there is little time to give to preventive or forward thinking slanted toward new equipment for the next generation of designs and operational techniques. Further, the air line engineer, and his bosses, not feeling the immediate responsibility for the next design, are reluctant to inject their ideas and standards criteria into the "preliminary design" phase. And certainly if they did, it might be considered an intrusion by the design engineer, and probably resented. Yet the time to take advantage of operating experience is when it is fresh and significant.

Perhaps the initiative in this cooperative venture can best be assumed by the design engineer and manufacturer. There will be less likelihood of embarrassment and misunderstanding than if the initiative is assumed by the user or consumer.

Cooperation Through the ASTM

I would be negligent if I did not acknowledge at this time the important contribution currently being made by the American Society for Testing Materials in the development of civil aircraft turbine fuel specifications. The original request on the behalf of the air lines was initiated by the Air Transport Assn.

First there was a question of why the air lines should need or desire new civil turbine fuel specifications at all. Was it not true that the military have already done this for us? Was it not true that in any case we must accept fuels already in production? It seemed obvious to many that the air lines should take advantage of already existing specifications and manufacturing methods, and forget their special needs.

First of all, let me say that there are basic differences in the needs and responsibilities of the air lines as compared with the military. Military fuel specifications are designed to anticipate the effects of possible emergencies. Therefore, they must envision and plan for the greatest and most extensive sources of supply. Their specifications must be as broad as possible. Ultimate equipment reliability and economy are secondary.

By contrast, the air lines are primarily concerned with safety, economy, and operational reliability in day-in and day-out operations. They must be sure that the fuel at every refueling point will not vary from day to day and can be depended upon to provide consistent power, economy, and service life for the equipment. Payload or range or both can be significantly affected by fuel specification variations. Cost is of utmost importance to air lines. Variation of 1 cent per gallon in the cost of the fuel represents roughly $2\frac{1}{2}$ per cent variation in direct operating cost for turbine aircraft. The objective must be a fuel specification which will be adequate to insure consistent power and safety and yet at the same time will not unduly limit the supply or cause too high a cost.

The manufacturers, both engine and airframe, have their own ideas as to the proper fuel characteristics. They envision operations in all climates and altitudes throughout the world. They also are concerned with the various operators' abilities and judgment, especially as they may affect warranties and performance guarantees. They, too, are safety conscious. Therefore their "blanket" fuel specifications may be even more restrictive and conservative than is justified for a specific operation. Each fuel supplier has a product or products that seem to him to fit the civil turbine fuel requirements. He would like to market it as is. That would enable him to be most competitive in the civil turbine fuel market. The sale of this product would cause him minimum inconvenience and cost with respect to manufacture, storage, and handling.

The air lines have the biggest stake in this problem. They must pay for the fuel they choose and must accept responsibility to the public for safety and schedule reliability. Up to the present time, at least, they have had very little extensive operating experience on which to base their judgment of turbine fuel specification requirements. They do know that they need a special product for efficient day-to-day operations.

This situation caused them to turn to ASTM for assistance. While fully agreed-upon civil specifications have not as yet been published, the numerous meetings, discussions, and tentative specifications have resulted in a disclosure of many facts and data important to the final resolution of the requirement. Through the good offices of ASTM, there has come a better understanding of the significant positions of each of the parties than could have been achieved through limited buyer-seller negotiations. In this cooperative program we have seen many evidences of the objective approach to a problem vitally important to the air lines and their customers and to the national welfare. The ASTM meetings have demonstrated the sincere "give and take" attitude on the part of all, which, as stated in this paper, is so essential in the achievement of effective standardization objectives.

Unlimited Horizons for Industrial Use of Radioisotopes

AT THE Symposium on Radioactive Isotopes during the ASTM Second Pacific Area National Meeting in September, 1956, an extremely significant contribution to the discussion was made by Paul C. Aebersold, director of Isotopes Ext., Division of Civil Application, Atomic Energy Commission. Dr. Aebersold was the 1948 ASTM Edgar Marburg Lecturer on the subject "Isotopes and Their Application in the Field of Industrial Materials." The text of this 1957 discussion seemed to be of so much interest to all readers of the ASTM BULLETIN that it is being reproduced below. The entire publication will be available within the next month.

As a bio-physicist, I have no place appearing before people in industrial engineering. That is the way I felt when I was invited in 1948 to give the Edgar Marburg Lecture before this Society. I did not know much about the Society, but I soon found, of course, that it had considerable prewar interest in nondestructive testing by means of radiation with both X-rays and radioactive materials. The Society is to be congratulated for taking a very early interest in the use of the postwar reactor products in this field.

In my 1948 lecture I could present only basic principles of the way isotopes might be used in industry. There were very few actual applications in industry at that time, and not over a hundred industrial firms using isotopes in 1948. Those groups were using them mainly in research and development programs, and these programs have paid off well.

I predicted that there were great potential values in the use of isotopes—that they could have great economic value—and this has been borne out. In the past five years there has been a tremendous growth in the industrial uses of radioisotopes. The number of users has increased by perhaps a factor of 15. There are over 2000 industrial groups using radioisotopes, and, as has been pointed out, there are over 3000 beta gages alone in use in industry. There are many other types of gages. The applications are quite diverse.

To estimate the savings from the use of thickness gages, assume there are 3000 gages and each gage saves only $40,000 a year. This is not a very great amount because some gages save much more than that, not only in manpower and materials but in reduced shutdown time and better operation, better product, and so on. If you take only $40,000 per gage and multiply it by 3000 gages you have $120,000,000, which is a substantial saving to industry. Another extensive use in the field of nondestructive testing, of course, is radiography, where a few thousand radiographic sources are in use by about 500 institutions. Estimates have been made of all the over-all savings from radioisotopes used in industry and these run to several hundreds of millions of dollars per year.

One could go on about the increase in usefulness, the savings, and so on. It has been encouraging to see this growth, yet it has not been anything to what it could be. The potential still is very great. The number of industrial users that could derive economic and other benefits from the use of radioisotopes is very great indeed, so that the potential savings could run into billions of dollars per year.

Therefore, while commending the groups that have pioneered in this field and being encouraged by their developments, one might also ask why has there not been an even greater use of these materials. At first there might have been a shortage of isotopes, but I doubt if that is going to occur again. Reactors are being built all over the country. We will produce this year a total of several hundred thousand curies of cobalt-60 alone, and we have a proposed program to produce millions of curies for use in the field of applied radiation.

In addition, we are building a fission product pilot plant. It will produce over 200,000 curies per year of cesium-137, a major gamma ray emitting fission product. It can also produce as many curies of strontium-90 and other fission products. This plant is being built to show what can be obtained from radioactive waste products. If one considers that there will be many power reactors throughout the country, the total quantity of fission products will be enormous. There is thus no longer a shortage in basic by-products, radioactive isotopes, and fission products.

Also, there is no shortage of instrumentation. Radiation instrumentation has developed greatly since ten years ago. It is not only more reliable but there are more sensitive types of instruments, including scintillation counters, both with solid detectors and liquid scintillators. The variety of detection schemes can be great indeed.

In addition, isotope know-how has increased greatly. The number of technical papers presented, not only in this Society but in many other societies, on uses of radioisotopes, has resulted in a large volume of information.

What then is the deterrent at present? A major item is the lack of trained personnel. You need training beyond what you now get in college, usually in engineering, or even in science curricula, to handle radioisotopes safely. There is always some degree of radiation hazard involved, but it does not take a large amount of training to learn how to handle this properly. You need not be a nuclear engineer to take advantage of most uses

(*Continued on page 71*)

Proposed Method of Test for

Measurement of Extreme Pressure Properties of Lubricants

(Published as information only)

This report supplements the September, 1956,[1] report of the Special Committee on Measurement of Extreme Pressure Properties[2] of ASTM Committee D-2 on Petroleum Products and Lubricants. The procedure described herein embodies the recommendation of this committee relative to a preferred method for operating the Timken Tester based upon the experience accumulated in the various cooperative programs initiated by this group.

Scope

1. This method describes a procedure for the determination of the load-carrying capacity of lubricating oils and lubricating greases by means of the Timken Extreme Pressure Tester.

NOTE 1.—The results do not necessarily correlate well with those from other bench scale apparatus or with results from service. However, the method forms a part of many specifications and considerable experience with this machine has been accumulated. For these reasons the procedure is published for information.

Definitions

2. (*a*) *Load-Bearing Capacity* of a lubricant is the maximum load or pressure which can be sustained by the lubricant (when used in a given system under specific conditions) without permitting failure of moving bearings or sliding contact surfaces as evidenced by adverse physical changes attributable to direct contact between them such as seizure or welding.

(*b*) *Seizure* is the localized fusion of metal between rubbing surfaces of the test specimens. It is usually indicated by an increase in friction and wear. Unusual noise or appearance of streaks on the surface of the test cup are usually the first indications of seizure.

NOTE 2.—Galling and scuffing are common synonyms for seizure.

(*c*) *Welding* is the fusion of metals between rubbing surfaces.

(*d*) *Wear* is the removal of metal from a test specimen whether by a mechanical process or by a combination of mechanical and chemical actions.

(*e*) *Scoring.*—When no breakdown of the lubricant film occurs, a smooth scar is obtained on the test block. When the lubricant film does break, surface failure of the test block takes place as shown in Fig. 1. In its simplest and most recognized form it is characterized by the furrowed appearance of a wide scar and by excessive pick-up of metal on the surface of the test cup. The form of surface failure more usually encountered, however, is a comparatively smooth scar which shows local damage that usually extends beyond the width of the scar.

(*f*) *OK Value* is the maximum weight, in pounds added to the weight pan, at which no scoring or seizure occurs.

(*g*) *Score Value* is the minimum weight, in pounds added to the weight pan, at which scoring or seizure occurs.

Outline of Method

3. (*a*) Oil samples are preheated to 100 ± 5 F before starting the test with no control on the oil temperature during the 10-min test run. Grease samples are applied to the test specimens at room temperature at a uniform rate of 0.04 to 0.1 lb per min. The machine is operated at such a rate that the rubbing speed of the test cup on the block is 400 ± 2.5 ft per min.

(*b*) The minimum load at which a rotating cup will rupture a film of the lubricant being tested between it and a stationary block and cause abrasion (score) of the stationary block is determined. The maximum load at which the rotating cup will not rupture the film of lubricant and cause abrasion of the stationary block (OK load) is also determined.

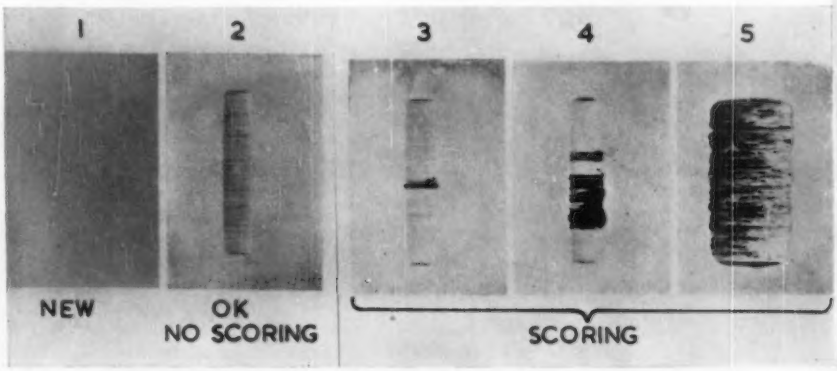


Fig. 1.—Timken test blocks with various types of scar.

[1] ASTM BULLETIN, No. 216, Sept. 1956, p. 25.

[2] Members of the Special Committee are: P. A. Asseff, Chairman; J. S. Aarons, H. E. Achilles, C. J. Boner, L. C. Brunstrom, E. S. Carmichael, H. Crabbe, T. E. DeVilliers, M. Ehrlich, H. A. Erickson, A. P. Evans, J. H. Evans, R. E. Fariss, N. J. Gothard, C. D. Greene, P. R. Izdepski, R. H. Jenks, H. W. Kayser, F. I. L. Lawerence, H. L. Leland, C. T. Lewis, C. M. Loane, H. E. Luntz, M. C. McLaren, C. C. Moore, R. G. Moyer, T. Paterson, H. T. Peeples, L. B. Sargent, N. L. Shaw, A. Sonntag, M. D. Stone, F. D. Tuemmler, P. H. White, D. E. Whitehead, O. M. Windrath, and H. C. Zweifel.

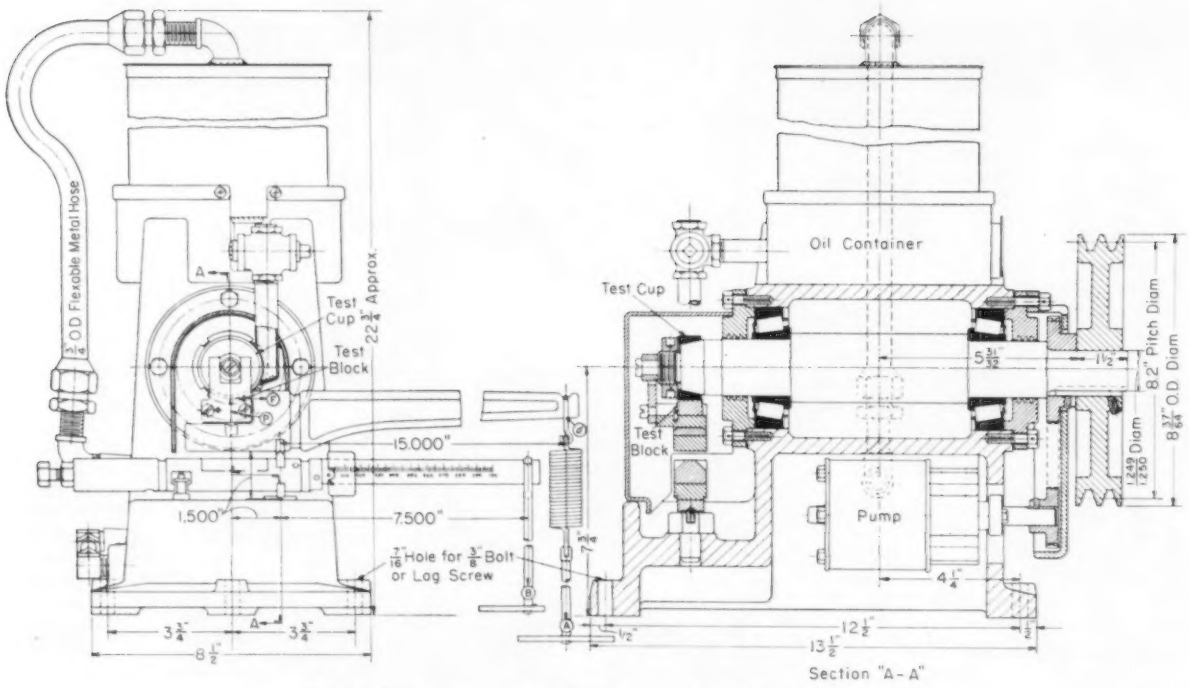


Fig. 2.—Sectional view of Timken extreme pressure machine.

Formulae:
A—Load lever weight
B—Friction lever weight
C—Load lever constant—upward pressure acting at point "*d*" which will balance load lever with weight hanger in place
F—Friction
P—Test pressure
R—Sliding weight reading
μ – Friction coefficient
L—Length of scar on test block
W—Width of scar
S—Pressure, per sq. in. on test block

$$P = 10\,(A + C) - 2\tfrac{1}{2}\,(B + R)$$

$$F = 9.45\,(B + R)$$

$$\mu = \frac{F}{P} = \frac{3.78\,(B + R)}{4\,(A + C) - (B + R)}$$

$$S = \frac{P}{W \times L}$$

Apparatus

(*a*) *Timken Extreme Pressure Machine*, illustrated in Fig. 2, is described in detail in the Appendix.

(*b*) *Sample Feed Devices* for flooding the test specimens with oil or with grease are described in the Appendix.

(*c*) *Loading Mechanism*, automatic, for applying and removing the load weights at a uniform rate without shock; the loading rate shall be between 2 and 3 lb per sec. A more complete description appears in the Appendix.

(*d*) *Microscope*, low power (×50 ×60), having sufficient clearance under the objective to accommodate the test block. It should be fitted with a filar micrometer so that scar width may be measured with an accuracy of ±0.002 in.

Materials

5. (*a*) *Test Cups* resembling the outer race of a small Timken roller bearing, of steel having a Rockwell hardness C scale number of 58 to 62 or a Diamond Pyramid hardness number of 654 to 746. The required rings have a face 0.5 in. wide, a perimeter of 6 in. and a concentricity between the inner and outer surfaces of ±0.0005 in. The new Timken closely controlled surface finish cups[3] are supplied and should be used; the total variation in surface finish should not exceed 10 microinches, and the average surface roughness should lie between 20 and 30 microinches.

(*b*) *Test Blocks*, ½ in. square and ¾ in. long of carburized steel having a Rockwell hardness C scale number of 58 to 62 or a Diamond Pyramid hardness number of 654 to 746. Each block is supplied with the four test faces ground to a standard finish.[3]

(*c*) *Acetone*, conforming to ASTM Tentative Specification for Acetone (D 329 – 55T).[4]

(*d*) *Naphtha*, conforming to the ASTM Specification for Stoddard Solvent (D 484 – 52).[5]

Check Test Standards[1]

6. (*a*) Prepare at periods not exceeding 6 months, a blend containing 8.0 ± 0.1 per cent by weight methyl dichlorosterate[6] and 6.6 ± 0.1 per cent by weight hexachloroethane[7] (melting point 185 to 194 F) and 85.4 ± 0.2 per cent by weight solvent refined mineral oil having a viscosity of 16.78 to 18.14 cs at 210 F (85 to 90 Saybolt Universal sec (SUS). Heat the oil to 210 F and add the hexachloroethane slowly with stirring over a period of 15 min after all the additive is completely dissolved. Then cool the mixture to 170 F and add the methyl dichlorostearate and maintain at 120 to 140 F for 30 min with constant stirring. Designate this mixture as blend A.

(*b*) Prepare an equivoluminal mixture of blend A with the base oil and designate as blend B. Similarly, prepare an equivoluminal mixture of blend B with the base oil and designate as blend C; an equivoluminal mixture of blend C with base oil and designate as blend D; and an equivoluminal mixture of blend D with base oil and designate as blend E.

(*c*) Refer to section 8 for recommended use of these standards.

[3] Available from the Timken Roller Bearing Co. or British Timken Ltd., under part No. T-48651 for test cups and No. T-45349 for the test blocks.
[4] 1955 Book of ASTM Standards, Part 5, p. 367.
[5] 1955 Book of ASTM Standards, Part 5, p. 242.
[6] Manufactured by Matheson Co., East Rutherford, N. J., under designation of ASTM Grade.
[7] Manufactured by Distillation Products Industries, Division of Eastman Kodak Co., Rochester, N. Y., under catalog No. 144.

TABLE I.—COOPERATIVE TEST RESULTS ON MEASUREMENT OF EXTREME PRESSURE PROPERTIES OF LUBRICANTS BY TIMKEN MACHINE.

Laboratory	Timken OK Results on Grease Samples	
	Sample No. 1	Sample No. 2
1	.....	65, 65
2	25, 30, 30	45
3	35, 35, 35	50, 55, 55
4	38, 38	.....
5	.....	65
6	40, 40	50, 50
7	.....	50, 50, 55
8	30	55
9	35, 35	40, 50, 45
10	35, 35	55, 55
11	40, 40	60, 50, 50
12	23, 33	40, 45, 50
13	40	60
14	.....	55
SUMMARY		
Number of determinations	20	26
Range	23–40	40–65
Average	34.7	52.5
Standard deviation	4.7	6.8
Variation, per cent	13.5	13.0

TABLE II.—COOPERATIVE TEST RESULTS ON MEASUREMENT OF EXTREME PRESSURE PROPERTIES OF LUBRICANTS BY TIMKEN MACHINE.

Laboratory:	Timken OK Results on Liquid Standards					
	Blend A	Blend B	Blend C	Blend D	Blend E	OS No. 4047
1	40	60	40	30	20	45
2	95	60	50	28	28	40
3	60	50	30	25	28	40
4	100	80	55	35	18	...
5	100	80	45	30	15	65
6	80	45	35	20	15	60
7	80	60	45	25	15	...
8	80	55	35	30	18	65
9	80	70	40	28	15	70
10	70	70	60	35	30	65
11	85	85	45	22	13	...
14	65	60	28	20	18	55
15	70	60	45	30	24	60
16	75	70	45	25	18	60
SUMMARY						
Number of determinations	14	14	14	14	14	11
Arithmetic mean	77.14	64.64	42.71	27.36	19.64	56.82
Standard deviation	15.55	11.25	8.62	4.62	5.39	10.06
Variation, per cent	20.15	17.40	20.18	16.89	27.44	17.70
Range	40 to 100	45 to 85	28 to 60	20 to 35	13 to 30	40 to 70

TABLE III.—COOPERATIVE TEST RESULTS ON MEASUREMENT OF EXTREME PRESSURE PROPERTIES OF LUBRICANTS BY TIMKEN MACHINE.

Machine	Timken OK Results on Liquid Standards—New Machines		
	Blend A	Blend B	Blend C
W 214	90	75	25
W 218	85	70	25
W 219	90	75	28

Apparatus Preparation

7. (*a*) Before testing a new oil, flush the machine with Stoddard solvent and then with 1 qt of the oil to be tested, and discard. Fill the oil reservoir with 3 qt of the oil to be tested.

(*b*) Select a new test cup and a new surface of the test block each time the load is changed. When seizure has occurred, discard the entire test block since excessive heat, developed when deep scarring occurs, may alter the surface characteristics of the entire block. Wash the test cups and blocks with Stoddard solvent (see Note 3) within 1 hr prior to their use and then dry with a clean, soft cloth or paper.

NOTE 3.—Do not use a solvent such as carbon tetrachloride which may have antifriction qualities.

(*c*) Assemble the machine carefully, placing the test cup on the spindle, making certain that it is well seated, but avoid excessive tightening. Place the test block in the special holder and adjust the lever so that all the knife edges are in proper alignment. Special care should be exercised in placing the stirrup of the weight platform in the groove of the lever arm to avoid premature shock to the specimen block. Also, make sure that the load is distributed evenly across the groove in the lever arm. Smear the cup and block with the lubricant to be tested and rotate the machine by hand a few revolutions. If the parts are in alignment, the lubricant will be cleaned off the cup over its entire width. The eccentricity of the cup as placed on the spindle should not be more than 0.0006 in. and the maximum shaft deflection not more than 0.001 in. under a load of 50 lb.

(*d*) For the testing of greases, clean the apparatus with naphtha and acetone, as described above, and blow the apparatus dry. Disconnect the pump and shield the sump. Replace the oil container with the grease gun filled with sample.

Apparatus Check

8. The purpose of this check is to determine when a unit has changed to the point where questionable results are obtained. It is recommended that the machine be checked at frequent intervals, at least every six months, using the series of liquid standards described in section 6. If the values obtained do not fall within the following limits, the apparatus should be thoroughly checked for conformance to manufacturer's tolerances, and rebuilt to conform whenever necessary:

Blend A	75 to 100
Blend B	65 to 85
Blend C	45 to 60
Blend D	25 to 35
Blend E	15 to 30

NOTE 4.—These limits were suggested by the data given in Tables II and III.

Procedure

9. *Lubricating Oils*

(*a*) Fill the upper reservoir of the machine to within 3 in. of the top and preheat sample (approximately 3 qt) to 100 ± 5 F. Circulate the oil for 15 min, under no load at this temperature. After each successive load the oil should be cooled back to the 100 ± 5 F starting temperature.

(*b*) Set the valve opening so that an oil of 875 to 1155 SUS at 100 F will have a flow rate of 1500 to 4100 ml per min. Allow the lubricant to flood the test cup and block. When the sump is about half filled with the lubricant, start the motor to revolve the spindle holding the test cup at 800 ± 5 rpm, thus producing a speed of the cup on the block of 400 ± 2.5 ft per min. Check the spindle rotation speed frequently.

(*c*) After the break-in period of 30 to 60 sec, apply a load which is less than the expected score load (see Note 4), then allow the machine to run for 10 ± 1 min unless a score is noticeable before that period. Care must be taken to apply the entire load at a rate of 2.5 ± 0.5 lb per sec and with a minimum of shock loading which is a source of discrepancies in results; for this reason the automatic loader is required. In use, the lever adjustment, just previous to applying the load, must be such that the spindle is just free of the force of the weights.

NOTE 5.—In the absence of a better estimate, a starting load of 30 lb is recommended.

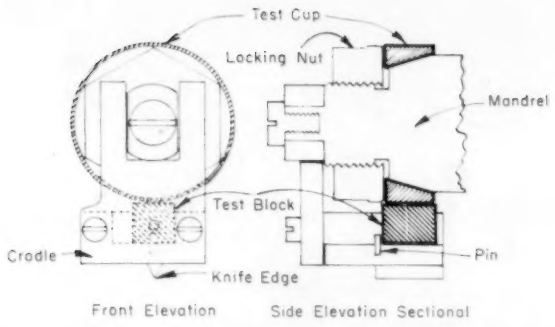


Fig. 3.—Diagram of Timken wear and lubricant testing machine showing assembly of test pieces.

(*d*) After the load has been applied, adjust any decrease in speed resulting from the application of the load. If, however, at the application of the load or during the subsequent test period, a decrease in speed of greater than 50 rpm, accompanied by excessive noise occurs, remove the load and stop the machine at once because scoring of the block has occurred. Then turn off the oil flow. When seizure occurs, discard the test block since the excessive heat developed with deep scoring may alter the surface characteristics of the entire block.

(*e*) If no scoring has occurred, allow the machine to run for 10 min from the start of the application of the load. At the end of the 10-min period, reverse the loading device and remove the load from the lever arm. Turn off the motor, allow the spindle to come to rest, then turn off the flow of lubricant. Remove the load lever arm and inspect the condition of the test block surface. The lubricant has failed at the imposed load if the wear scar indicates any scoring or welding.

(*f*) If no score is observed, turn the test block to expose a new surface of contact and, with a new test cup, repeat the test with a load 10 lb heavier and increase it in 10-lb increments until a load which produces a score is reached. At this point decrease the load in 5-lb decrements until the load does not produce a score. In the event that the OK and score loads are the same, the test should be rerun twice at this load and the two results which are in agreement should be taken as the valid result.

(*g*) In the event that a score is produced at the 30-lb load, the load should be reduced by 6-lb decrements until an OK is realized. At this point the load should be increased in increments of 3 lb until a score is obtained.

(*h*) When a borderline result is obtained at any load, such as illustrated in Fig. 1 (*3*), repeat the test at that same load and if the two results are in agreement, consider a score having been made. If the second test is an OK, make a third run and record the two tests that agree as the result at that load.

10. *Lubricating Greases*

Replace the oil reservoir with the filled grease gun. Grease the cup and block and thoroughly grease the bushing with a little of the sample. Do not heat the grease gun. Apply the grease to the test block through the motor-driven piston at the uniform rate of 0.04 to 0.1 lb per min. Determine the Timken OK value of the grease as described in section 9(*c*) through 9(*h*).

11. *Other Tests*

Contact Pressure, if desired. After the maximum (OK) load at which no seizure occurs has been identified, remove the test block and wash with naphtha. By means of a filar micrometer microscope, measure the width of the scars on those blocks which successfully carried this load. Make all measurements to 0.002 in.

Calculation

12. (*a*) Report the OK and score values in terms of the weights placed on the weight pan hanging from the end of the lever arm; this does not include the weight of the pan assembly. Report the values in multiples of 5 lb above 30 lb and in multiples of 3 below 30 lb. The OK value is the load-bearing capacity of the sample by the Timken test.

(*b*) When desired, the contact (unit) pressure which exists between the cup and block at the conclusion of the test may be calculated by means of the following equation:

$$\text{Contact Pressure, psi} = \frac{L(W + G)}{d \times s} = \frac{10(W + G)}{0.5s}$$

where:

L = lever arm ratio, 10,
G = load lever constant (that is, the upward force required to balance the load lever with its test block, cradle, spring, and weight hanger in place). This usually runs about 1.5 lb,
W = weight, lb, placed on the weight pan,
d = length of test scar, $\frac{1}{2}$ in., and
s = average width of test scar, in.

Precision

13. Cooperative data obtained by this method are reported by the sponsoring committee in the ASTM BULLETIN for April, 1952, No. 181 and for September, 1956, No. 216. Typical data from these publications for oils and greases are shown in the Tables.

Since the precision of the Timken test is generally poor, small differences between Timken values on lubricants do not necessarily indicate a significant difference in extreme pressure properties. However, the Timken method does differentiate between lubricants having different levels of extreme pressure properties, namely low, medium, or high.

APPENDIX

Apparatus Description

1. *Timken Extreme Pressure Machine*[8] (see Figs. 2 and 3) consisting essentially of a horizontal rigid spindle mounted in two substantial roller bearings and rotated at a constant speed of 800 ± 5 rpm by means of a 2-hp synchronous motor. It is important that the machine be rigidly mounted. A hardened steel test block is mounted in a cradle upon knife-edge bearings which are designed to promote correct alignment and uniform pressure distribution between the test cup, mounted on the rotating spindle, and the block.

(*a*) *Cradle*, fitted with a pin, and provided with a steel wedge so that the test block can be held in a position below the cup (see Fig. 3). The cradle is fitted with a pair of arms which fit around a phosphor-bronze bushing on the mandrel, and so hold it in place. The bottom of the cradle is mounted on the load lever by means of knife-edge bearings.

(*b*) *Test Cup Spindle*, tapered at the operating end to receive the test cup, which is locked in position by means of a locking ring or nut with a left-hand screw thread. The speed of the mandrel, 800 ± 5 rpm is measured by a tachometer either attached or applied to the shaft at frequent intervals.

[8] This machine was originally described in "Lubricant Testing," by E. G. Boden and O. L. Maag, ASME Meeting, May 22, 1931.

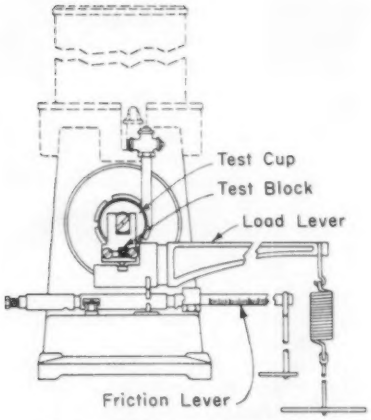


Fig. 4.—Timken extreme pressure machine—cutaway view.

(*c*) *Lever Systems* (see Fig. 2) consisting of two levers, the upper being the load lever and the lower the friction lever. The load (upper) lever carries the test block and is mounted on the lower lever by means of knife edges. The lower or friction lever is pivoted on a universal knife edge and is provided with a stop at the unloaded end.

(*d*) *Unbalanced Load.*—The load lever (see Fig. 4) is used to force the block upward against the test cup with a mechanical advantage of ten; that is, 1 lb placed on the notch at the outer end of the lever will exert a force of 10 lb on the test block. With the test block and holder in place, and the weight pan and loading spring suspended from the notch on the lever arm, determine to the nearest 2 oz the weight (force) required to balance the lever arm lever; use a platform balance and adjust this weight, if required, to 15 lb ± 2 oz.

(*e*) *Liquid Sample Container.*—The machine is provided with a 1-gal lubricant reservoir and piping to allow gravity flow of the test lubricant over the test blocks. During the running of the test, the reservoir should be firmly secured by the setscrews provided. A filter in the return line containing a 100-mesh or finer screen is useful in preventing wear particles from entering the oil system when testing under successively lower loads after scoring. A magnet placed over the intake is also quite helpful in this respect. The reservoir is fitted with electric heaters of approximately 100-w capacity and a thermometer in its delivery spout so that the temperature of the lubricant may be controlled at 100 ± 5 F at the beginning of the test. A water-cooled mechanism may be installed in order to bring the temperature down to 100 ± 5 F more rapidly before starting a determination.

(*f*) *Oil Sample Feed.*—A pump in the base of the machine removes the used lubricant from the sump and returns it to the reservoir. The rate of flow from the reservoir to the test blocks should be maintained in accordance with the instructions given under section 9(*b*) of Procedure.

[9] Manufactured by Pavlik Brothers, Kenilworth, Ill.

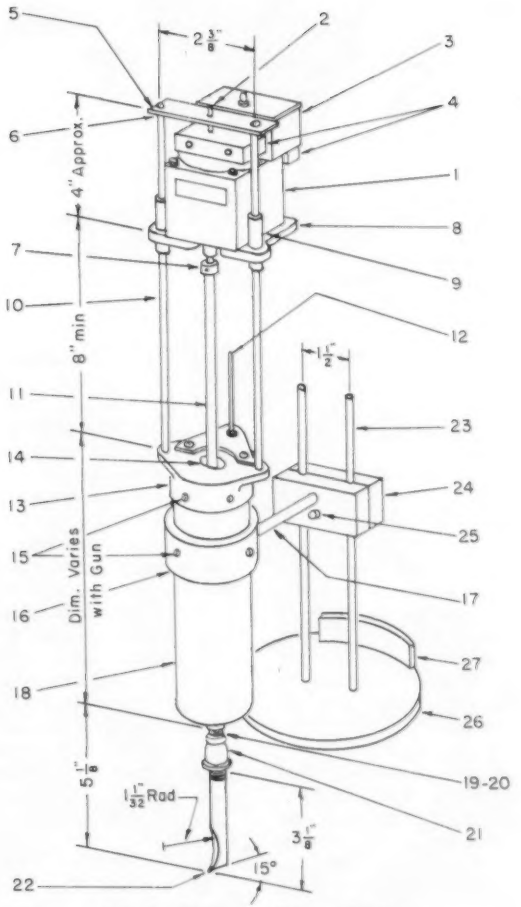


Fig. 5.—Grease feeding mechanism.

1. Bodine motor: No. KCI-22RC, 1/2000 hp, 60 cycle, 1260 rpm, 180:1 gear ratio, 7 rpm output, 49 in.-oz torque, CC rotation.
2. Upper limit contact screw: adjustable
3. Container: condenser and reversible switch, 3 amp–125 v
4. Microswitches
5. Plate: 1 in. by 1/8 in. by 3 1/2 in. long
6. Drill and tap rod for No. 10–24 NC screw
7. Coupling: pin type
8. Motor mount plate: 1/4 in. thick
9. Brass bushings: 1/8 in. ID by 1/2 in. OD by 1 1/2 in. long, with 5/8 in. diam shoulder: press fit into motor mount
10. Guide rods: 1/8 in. diam by 12 in. long, screwed into adapter cap, 1/4 in.—20 NC thread
11. Feed screw: 1/2 in.—20 NF thread by 8 in. long
12. Lower limit contact: 1/4 in. diam by 4 in. long—adjustable
13. Adapter cap
14. Hole in adapter cap: 1 1/8 in. diam
15. Setscrews
16. Mounting ring: aluminum
17. Rod: 1/4 in. diam by 7 in. long
18. Alemite gun: No. C-700 shown, 12 oz capacity, inside depth 6 1/4 in.
19. Close nipple—to suit grease gun
20. Bushing (if necessary)
21. Reducer: 1/8 in. by 1/2 in.
22. Standard pipe: 1/2 in. (cut as shown) plug bottom
23. Rods: 1/2 in. diam by 18 in. long
24. Split block: 2 in. by 2 3/4 in. long
25. Binding bolt: 3/8 in. diam
26. Base plate: 6 3/8 in. diam by 1/2 in. thick
27. Bar: 1 in. by 1/4 in. by 6 in. long (bend as shown) weld to base plate

(*g*) *Grease Sample Feed*, a cylindrical container capable of holding a 12-oz sample fitted with a motor-driven piston by means of which grease can be ejected from a bottom outlet at a uniform rate of 0.04 to 0.1 lb per min. (Fig. 5).

2. *Loading Mechanism*, automatic, for applying an effective loading rate of 2.5 ± 0.5 lb per sec to the lever arm of the Timken machine and for removing load weights uniformly and without shock.

(*a*) One device[9] which has proved to be satisfactory consists of a loading screw which is moved up and down by the rotation of a fixed bevel gear. The thread portion of the gear is identical with that of the load screw. The power is transmitted from the motor through a reduction box to a mating bevel gear The action of the loader is to support the weights on the load pan and to apply the load by removing the load platform from under the loading pan at the required loading rate.

(*b*) To obtain the correct loading rate requires an adjustment between the linear rate of the mechanical loader and the tension spring between the weights and the lever arm of the Timken machine. Suspend a 20-lb weight from the spring and note the elongation to the nearest 0.001 in. Divide the rate of fall of the loader in inches per second by elongation in inches per second to obtain the effective loading rate.

Autographic Stress-Strain Recorders* †

By RAYMOND R. BOUCHE and DOUGLAS R. TATE

AUTOGRAPHIC stress-strain recorders are commonplace pieces of equipment today both in production control and in the research laboratory. They make possible a record of each test, not only furnishing an immediate indication of the properties of the test specimen but also carrying a reserve of additional data for future reference. Recorders have been adapted to testing a variety of materials in addition to metals—concrete, wood, plastics, and many others.

The mechanisms employed to couple the recorder to the extensometer and to the testing machine have been many and varied. An ideal recorder would impose only an imperceptible load on the extensometer and load indicating system of the testing machine, yet at the same time be capable of following faithfully rapid changes in strain or testing machine load. Such an ideal may not always be attainable, but modern recorder systems have approached it closely with the adaptation of recent advances in transducers and servo-mechanisms.

It is the aim of this paper to present a description of the operating principles of some of the early successful stress-strain recorders and to show the sequence of changes which led to the development of the modern types of recorders. In addition, since there is little information available in published form on the accuracy of stress-strain recorders, performance tests are reported for three recorders representative of many in use today. It should be noted that there are patents owned

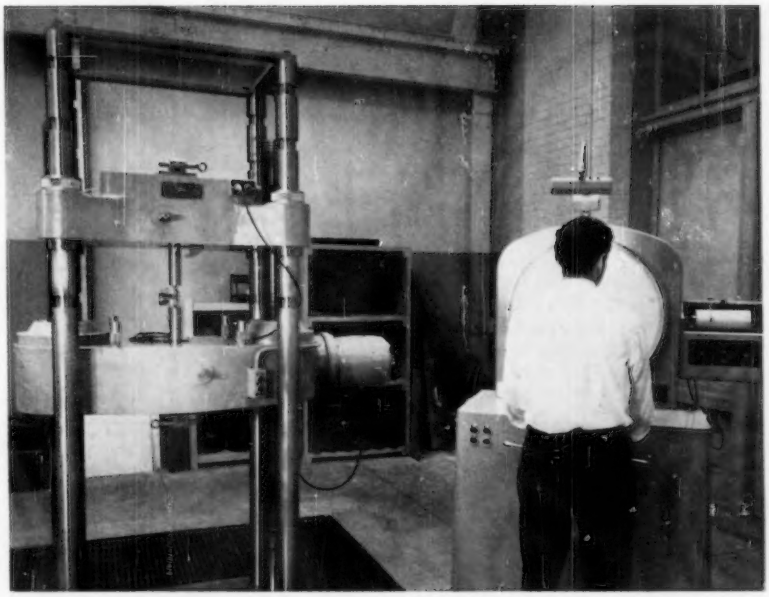


Fig. 1.—Autographic stress-strain recorder in operation. Recorder is in the process of drawing a typical stress-strain diagram of the specimen being tested.

R. R. BOUCHE, mechanical engineer in the Engineering Mechanics Section of the National Bureau of Standards, has been concerned with research work involving force, strain, and vibration-measuring devices for the past 7 years.

D. R. TATE, physicist in the Engineering Mechanics Section of the National Bureau of Standards, has been concerned with the performance of strain gages and load calibrating devices during the past 19 years. He has also taken an active part in ASTM committee work in the field of hardness measurements.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

* This investigation was conducted under a cooperative program of Basic Instrumentation Research and Development sponsored by the Office of Naval Research, the Office of Scientific Research of the Air Research and Development Command, and the Atomic Energy Commission.

† Presented at the Sixtieth Annual Meeting of the Society, June 16–21, 1957.

by recorder manufacturers; consequently no representation is made in this paper as to there being any freedom from patent aspects.

The descriptions which follow are largely of recorders for metals testing, such as that illustrated in Fig. 1. However, many of the instruments are available with modifications adapting them to other materials. The interpretation of the stress-strain curve in its application to structural design and the technique of mechanical testing has been well described (**1–21**)[1] in the literature.

A listing of contemporary manufacturers of stress-strain recording systems together with pertinent data on the equipment is given in Table I.

Mechanical Recorders

Recorders using only mechanical principles were described in the literature at the beginning of the twentieth century (**22–29**). Recorders using these same basic principles are still used on a small scale in some research laboratories today. Typical of these was the Kennedy pointer type recorder which used a mechanical linkage to actuate a scriber on a smoked glass plate.

Olsen and Riehle, manufacturers in this country, put mechanical recorders on the commercial market over 50 years ago. These recorders rotate a drum in proportion to the movement of the testing machine head, the drum rotation being only an approximation of the actual strain since slippage occurs between the testing machine grips and the specimen. The pen advances along the longitudinal axis of the drum by means of a mechanical linkage connected to the poise on the balance beam. The displacement of the poise is proportional to the load on the specimen. The diagram produced is a plot of stress *versus* approximate strain in the specimen.

Similar principles are employed in recorders in use today, particularly abroad (**30–33**). Strain is recorded by a metal cord attached directly to the straining head of the testing machine or to a suitable extensometer. The other end of the cord is wrapped around a pulley on the recorder drum. Constant tension is provided by a small weight. Thus, as the specimen is loaded, the drum is rotated in proportion to the displacement of the straining head. The load is recorded by a pen fixed to a rod that is mechanically geared to the load indicator of the testing machine.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

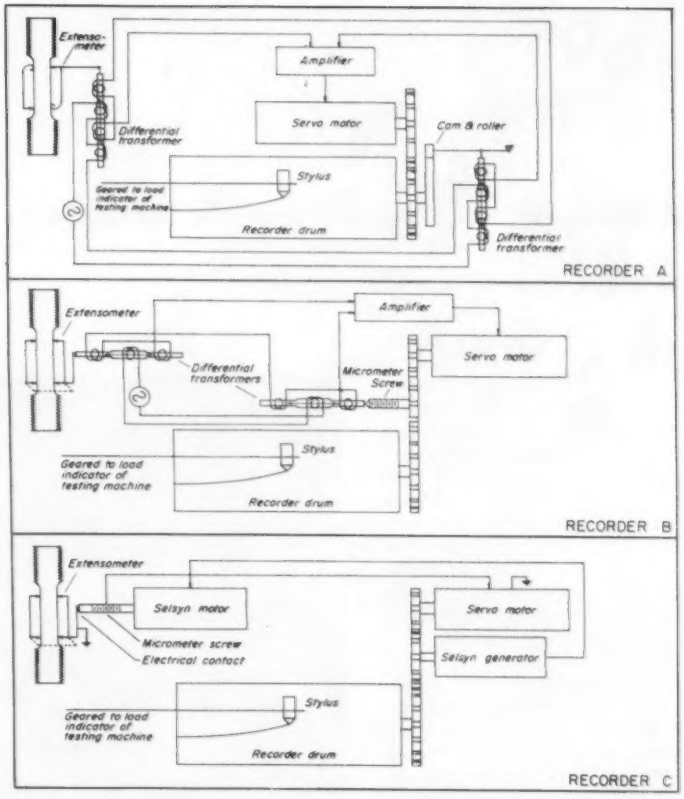


Fig. 2.—Schematic diagram showing operating principles used in three modern recorders widely used in the testing of metallic materials.

Mechanical-Electrical Recorders

The mechanical-electrical recorder uses mechanical principles for recording the stress and a combination of mechanical and electrical principles for recording the strain. The stress is recorded by a linkage between the load indicator of the testing machine and the pen of the recorder similar to that described above. Electrical-contact, variable-inductance, variable-resistance, or photoelectric principles are employed to provide a signal proportional to the extension of the specimen. This signal controls the rotation of the drum.

Electrical-Contact Principle

The electrical contact principle has been used since 1915 (**34**). The operator observes equal strain intervals indicated by an extensometer mounted on the specimen. At these intervals he depresses a push button which permits an electric motor to rotate the drum in equal steps. This results in a linear plot proportional to the extension of the specimen. Table I indicates that a recorder utilizing the "push button" principle of operation is still available from one manufacturer in this country.

Several methods (**34–37**) were employed to improve on this manually operated device. Finally, Smith (**38**) in 1927 produced the first fully automatic electrical-contact type recorder It was not readily accepted because it was necessary to mount the entire recorder unit directly upon the specimen. A few years later Templin (**39**) perfected the idea by making the recorder a separate unit and providing a light-weight extensometer for attachment to the specimen. This was a boon to routine tension testing because it provided extension magnifications up to 800. This recorder provided a rapid plot of the stress-strain curve from which the mechanical properties could be easily determined.

The electrical contact-type recorder is now a highly developed instrument found in many testing laboratories here and, to some extent, abroad. Recorder C, Fig. 2, illustrates the principle of operation in detail. As the specimen deforms, the electrical contact is broken, closing a relay (not shown)

Table 1 - Manufacturers of Stress-Strain Recorders

Manufacturer	Principle of Operation		Application to testing
	Extension	Load	
Alfred J. Amsler & Co. (American Representative: Adolph I. Buehler 228 North LaSalle Street Chicago, Illinois)	Mechanical	Mechanical	Tensile testing of metals in plastic range.
W. & T. Avery, Ltd. Soho Foundry Birmingham 40, England	Electrical contact	Mechanical	Tensile testing of metals in elastic and plastic ranges. Extensometers available for flats and rounds up to one inch in cross-section.
Baldwin-Lima-Hamilton Corp. Philadelphia 42, Pa.	a. Electrical contact b. Differential transformer c. Electric resistance strain gages	a. Mechanical b. Differential transformer c. Electric resistance strain gages	Tensile, compressive and specialty testing of metals in the elastic and plastic ranges. Extensometers available for flats and rounds from 0.005" to several inches in cross-section. Recorders also available for testing plastics, wood, concrete, etc.
Cambridge Instrument Co., Inc. Grand Central Terminal New York 17, New York	Electrical contact	Mechanical	Testing textiles, etc.
Samuel Denison & Son, Ltd. Hunslet Foundry Leeds 10, England	Mechanical	*	Testing of metals in plastic range. Also used for testing textiles.
W. C. Dillon & Co., Inc. 14620 Keswick Street Van Nuys, California	Mechanical	Mechanical	Testing of plastics, rubber, etc.
Instron Engineering Corp. 2 Hancock Street Quincy 71, Massachusetts	**	Electric resistance strain gages	Testing of plastics, rubber, textiles, etc.
Lorentzen & Wettres Maskinaffär Stockholm, Sweden	**	Electrical contact	Testing of plastics, rubber, paper, etc.
Losenhausenwerk Düsseldorf-Grafenberg Germany	Mechanical	Mechanical	Various instrumentation for metals testing.
National Forge & Ordnance Co. Irvine, Warren County, Pa.	Mechanical	Mechanical	Testing of paper cartons, etc.
Tinius Olsen Testing Machine Co. Willow Grove, Pennsylvania	a. Differential transformer b. Electro-magnetic	a. Mechanical b. Differential transformer	Tensile, compressive and specialty testing of metals in the elastic and plastic ranges. Extensometers available for flats and rounds from 0.005" to several inches in cross-section. Recorders also available for testing plastics, wood, concrete, etc.
Riehle Testing Machine Div. American Machine & Metals, Inc. East Moline, Illinois	a. Mechanical b. Photo-electric tube c. Push button operated d. Differential transformer	Mechanical	Testing of metals in elastic and plastic ranges. Recorders also available for testing fabrics, etc.
Scott Testers, Inc. Providence 1, Rhode Island	a. Mechanical b. **	a. Mechanical b. Electric resistance strain gages	Testing of plastics, rubber, etc.
Herbert Stein Regentenstrabe 37 M. Gladbach, Germany	**	Electric resistance strain gages	For testing of textiles.
Thwing-Albert Instrument Co. Penn Street & Pulaski Avenue Philadelphia 44, Pa.	**	Electric resistance strain gages	For testing plastics, rubber, textiles, etc.
Young Testing Machine Co. Skelton Building Byrn Mawr, Pennsylvania	Differential transformer	Mechanical	For testing of metals in elastic and plastic ranges. Extensometers available for rounds and flats.

* Sufficient information is not available to ascertain principle of operation.

** Extension or strain not recorded directly. The record along this coordinate is made at a uniform rate by means of a constant speed motor drive.

which permits the servo motor to turn the selsyn generator and the recorder drum. The selsyn generator drives the selsyn motor turning the micrometer screw until it closes the electrical contact and opens the relay. This process is repeated as the specimen deforms. Since the displacement of the electrical contact is proportional to the deformation in the specimen, the servo motor rotates the recorder drum in small steps in proportion to the strain in the specimen.

In England a similar electrical-contact type recorder is manufactured (40).

Variable-Inductance Principle

In competition with the electrical-contact recorder, several recorders utilizing magnetic principles (41) in the measurement of strain were developed. A stress-strain recorder was developed using a variable inductance extensometer (42) which imparted rotation to a drum by means of a relay and proper electrical circuitry. Finally, the differential transformer (43,44) with its movable core was applied to stress-strain recorders. It is a very satisfactory means of converting the mechanical displacement of the strained specimen into rotation of the recorder drum.

The differential-transformer type recorders, illustrated by recorders A and B in Fig. 2, are increasing in popularity in this country. The following steps explain the sequence of operation. As the specimen deforms, the core of a differential transformer is displaced relative to its windings. This produces an electrical signal which is amplified to provide power to the servo motor which rotates the recorder drum. Simultaneously, the core of a second differential transformer is displaced by either a cam or a micrometer screw in fixed proportion to the rotation of the recorder drum. The electrical output of the second transformer opposes the output of the first, so that eventually a balance is reached and the servo motor stops. The result is that the recorder drum follows the movement of the core of the extensometer transformer with so little lag and so smoothly that the resultant stress-strain curve appears to be almost stepless.

Variable-Resistance Principle

Electric-resistance strain gages are sometimes employed with stress-strain recording systems for recording strain (45). The strain-gage type recorder, which is not illustrated, employs an extensometer consisting of strain gages attached to a beam which is bent in accordance with the deformation of the specimen. Changes in resistance of the strain gages unbalance a Wheatstone bridge and actuate a self-balancing potentiometer to drive the recorder drum. This type of stress-strain recorder is not widely used.

Photoelectric Principle

One manufacturer, Table I, provides a recorder utilizing a photoelectric tube. A modified micrometer dial indicator interrupts light to the photoelectric tube. This tube provides a signal to an amplifier which powers a servo motor rotating the recorder drum in small steps.

Electrical Recorders

Several recorders use electrical principles for recording both stress and strain.

The stress is recorded through an electric-resistance strain-gage load cell (46,49–52) loaded in tandem with the specimen. The pen is moved along the load coordinate by a servo mechanism. In other recorders (53–55), differential-transformer load cells are also used for recording stress. One European manufacturer (see Table I) employs the electrical-contact principle to provide the motion for the load coordinate of the recorder.

Strain is recorded by using one of the electrical principles described above or by use of the "constant speed" principle, in which a constant speed drive on the recorder provides motion along the strain coordinate. If the straining head of the testing machine is driven by a positive mechanical gear drive and a constant speed motor, the resulting record will be a fair approximation of the actual extension of the specimen. This method is practicable where the extension of the specimen is large in relation to the grip slippage and the deformation in the machine components (56).

Optical Recorders

A recorder employing optical principles was developed in the World War I era. A hollow rod, loaded in tandem with the specimen, is provided with a mirror which rotates in proportion to the load. A second mirror is rotated in proportion to the extension in the specimen, about an axis perpendicular to the first axis. A light beam reflected by both mirrors provides a rectangular plot on a photographic negative. This device is known as the Dalby recorder (24,25). It does not lend itself to the rapid testing of materials because of the time required for photographic processing. This and other optical recorders are still used in Europe (47,48).

Recorders for Testing Metallic Materials

The bulk of the recorder systems in use today for metals in this country fall into the electro-mechanical class. A wide variety of extensometers is offered covering all standard test specimens and affording a choice of magnifications such that any portion of the stress-strain curve may be plotted. Recorder systems are designed so that the recorder is permanently attached to the testing machine and any of several extensometers may be selected according to the needs of the test (62–65). As a rule, the pen motion along the load axis is powered directly by the testing machine load indicator, but in cases where this would adversely affect the accuracy of load indications special servo devices can often be supplied.

Most stress-strain recorders plot conventional stress and strain. Although several devices for measuring true stress and true strain are described in the literature (66–72), most of these devices do not plot the stress-strain curve automatically.

The extensometers described are designed for short-time testing at temperatures between −100 and 200 F. However, standard models of extensometers mounted outside the furnace are suitable for certain laboratory tests at temperatures up to 2000 F. Although some recorders (73,74), not available commercially, have been developed for use in creep testing, special equipment usually is required. There is a continually increasing demand for materials capable of withstanding extreme temperatures. For example, modern aircraft utilize materials that must retain some strength at temperatures well above 2000 F. To determine the mechanical properties of materials at these temperatures, strain measuring devices for direct attachment to the hot specimen must be developed. Only a very few instruments (72,75) have been proposed for making measurements at such high temperatures. Considerable research work is now being directed toward the development of suitable resistive, inductive, or capacitive transducers (76–78) and of techniques for using them at high temperatures.

Recorders for Testing Nonmetallic Materials

Standard extensometers are available for many nonmetallic materials. However some rubber and plastic specimens are not sufficiently rigid to support an extensometer without the results of the test being affected. Consequently, recorders have been developed employing other principles of operation (49,50).

Some of these are described above. These recorders are less standardized than those used for testing metals. Therefore special recorders employing variations of the above-described physical principles appear frequently in the literature (**51–59**). Devices have also been developed to plot stress-strain curves of other materials such as suture cord (**60**) and refractories (**61**).

Performance Tests

Performance tests were made on three recorders and associated extensometers (Fig. 3) typical of some 2000 stress-strain recorders in use in mechanical testing laboratories in the United States. The principles of operation of these recorders are illustrated in Fig. 2. These recorders are referred to as recorder A, B, and C. The results of the performance tests should not be considered an evaluation of the performance of all recorders of these types.

The tolerances given in ASTM Method E 83 (**79**) for class B extensometers have been selected as a basis for the evaluation of the three extensometer and recorder combinations tested.

In testing the accuracy of load and extension indications of the three recorders, it was necessary to eliminate the

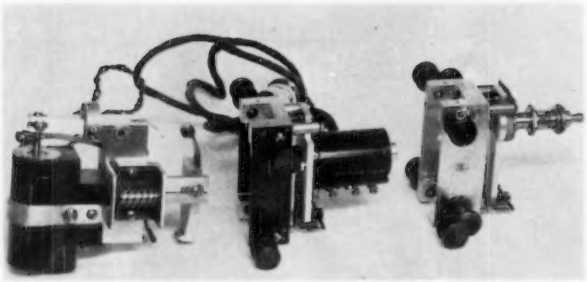


Fig. 3.—Extensometers, 2-in. gage length, averaging type, commonly used in the routine acceptance testing of metallic materials.

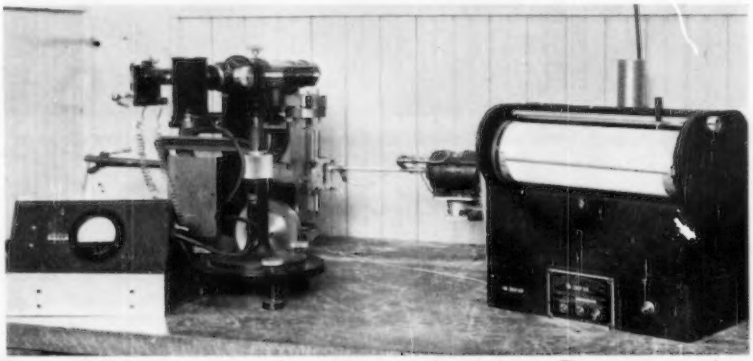


Fig. 4.—Calibration apparatus for strain-measuring devices. The apparatus, shown calibrating the strain coordinate of a recorder, includes an interferometer comparator and photoelectric counter.

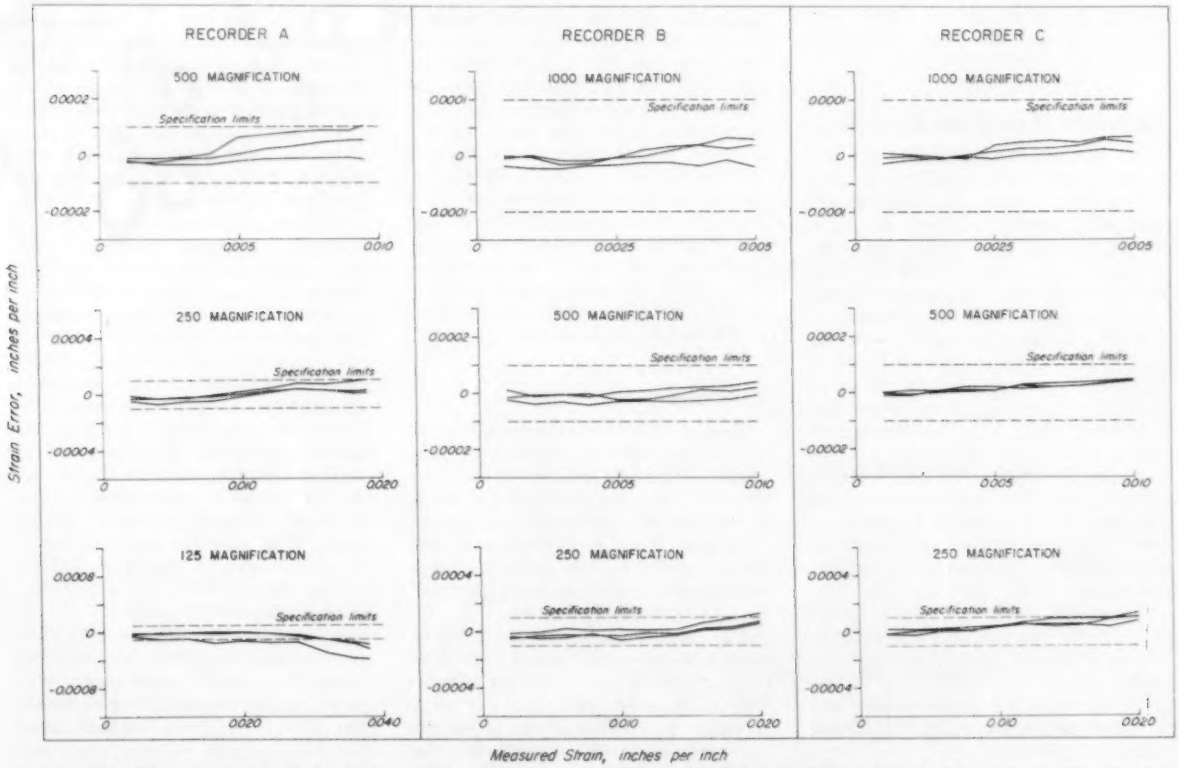


Fig. 5.—Calibration curves showing performance on the strain recording axis of three modern stress-strain recorders. Specification limits are ASTM tolerances for class B extensometers.

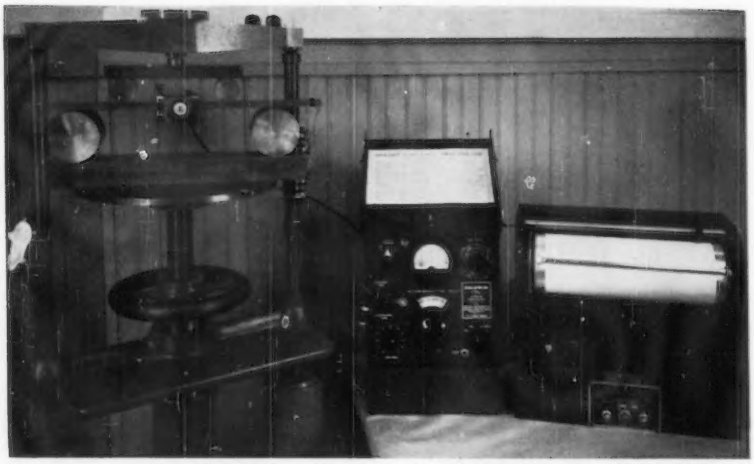


Fig. 6.—Test set-up used to evaluate the ability of extensometers to measure the average of unequal strains.

effects of expansion or contraction of the chart paper caused by humidity changes. The effects of humidity on the chart paper were evaluated separately. A record was made on the chart paper, but, instead of reading the values from the grid printed on the paper, the plotted values were obtained by measurement with an optical comparator having a sensitivity of 0.001 mm. Both load and extension coordinates were read soon after each test.

Calibration of the Strain Coordinate

The extensometers used in the test are all designed to respond to extension over a 2-in. gage length. Considerable apparatus (**80–88**) has been developed for calibration of displacement-measuring devices. For the tests described here, the calibration equipment consists of a comparator (**88**), with two coaxial $\frac{1}{2}$-in. bits placed end to end, a means for moving one bit with respect to the other along their common axis, and an interferometer arranged to measure the movement (Fig. 4). The interferometer is used in connection with a Pulfrich (**89**) viewing system and a helium light source. A photoelectric counter equipped with a meter for interpolation (**90**) is used to count the number of interference fringes corresponding to the displacement of the movable bit. The extensometer being calibrated is attached to the comparator. The calibration apparatus is sensitive to displacements smaller than 0.000001 in. The speed at which the extensometer was subjected to extension did not exceed 0.00005 in. per sec.

Each recorder and extensometer was calibrated three times for each of the three magnifications available on the recorders: 125, 250, and 500 or 250, 500, and 1000. The results of each of the three calibration runs are shown as separate curves in Fig. 5. The strain errors are the errors that would result if the user of the recorder assumes the extensometer's gage length is exactly 2 in. In other words, the correct value of the strain was the extension measured by the interferometer divided by the measured gage length of the extensometer, whereas the indicated strain on the chart paper was based on the extensometer's nominal gage length (2 in.). The specification limits shown in Fig. 5 are those given in ASTM Method E 83 (**79**) for class B extensometers. It is concluded that these particular recorders conform more readily to the requirements of class B extensometers when using extension magnifications of 1000 or 500 than when magnifications of 250 or 125 are employed.

Resolution

Resolution is here defined as the smallest applied extension necessary to cause motion of the pen relative to the chart paper. The apparatus used for determining the resolution was the same as that used for the calibration of the strain coordinate. In addition, a microscope was used to observe the small steps of rotation of the drum.

The extensometers were subjected to extensions at constant speed equivalent to 3 per cent of scale range per minute. Scale range is defined as that extension necessary to produce 10 in. of record. For example, at 1000 magnification the scale range is 0.010 in. extension. The extensometers were extended until 100 steps of rotation of the drum were observed with the microscope. The values of the resolution are listed in Table II.

TABLE II.—RESOLUTION OF STRESS-STRAIN RECORDERS.

Recorder	Extension Magnification	Resolution, in. of Extension
A	500	0.000009
B	1000	0.000004
C	1000	0.000015

Note that the resolutions of recorders A and B, the differential-transformer type, are finer than the resolution of recorder C, the electrical-contact type.

Averaging Test

This test was introduced to evaluate the effectiveness of the extensometer in averaging strain. In the actual testing of materials, it is unlikely that the strain will be equal in all fibers located in the periphery of the cross-section of the specimen. Therefore, it is necessary to measure the extension of two fibers diametrically opposed in order to determine the average strain. The extensometers, called "averaging type," are designed so that they will automatically measure the average strain.

The apparatus shown in Fig. 6 was devised for this test. A square section beam was loaded at two points so that a uniform bending moment was produced throughout the center section. The extensometer was attached with its gage points on the upper and lower surfaces of the beam in the center section. Thus one side of the extensometer was subjected to compression strain and the other to tension strain. The amount of strain was indicated by electric-resistance strain gages mounted on the beam within the gage length of the extensometer. The tension and compression strains were observed by means of the strain indicator in the center of the figure. The beam was loaded in a 300-lb capacity dead-weight testing machine.

The strain error, Fig. 7, is the amount the recorder strain deviated from the difference between the tension strain and the compression strain observed by means of the strain indicator. For example, if the tension and compression strains are equal in magnitude and the recorder drum does not rotate, the strain error would be zero.

Some of the strain differences to which the extensometers were subjected far exceed those which would normally be present in the tension testing of metals. Templin (**91**) and Smith (**66**) have shown that with suitable fixtures under controlled laboratory conditions, the difference in strain around the periphery of

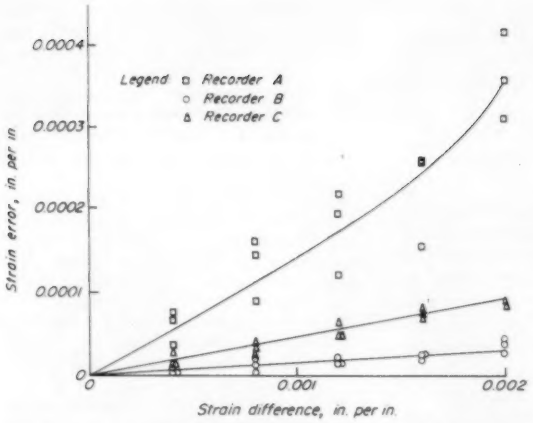


Fig. 7.—Test results which illustrate the ability of extensometers to measure the average of unequal strains. Tests were conducted on three modern stress-strain recorders.

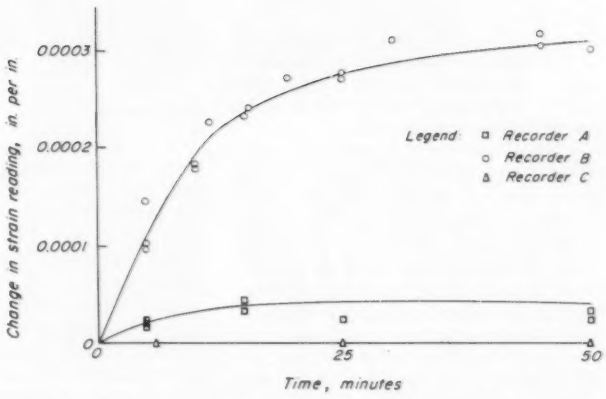


Fig. 8.—Test results which indicate the warm-up period required prior to operation of stress-strain recorders.

a tension test specimen is of the order of 0.0001. Smith (**66**) indicates that when using some types of self-aligning holders, variations may be several times as great. The results of Fig. 7 show that the strain errors for the extensometers are less than one fourth of the strain differences.

Warm-up Time

This test was conducted to determine how much time is required to achieve stability after the recorder is connected to a power supply and what the magnitude of any drift might be. The recorders, with extensometers attached, were turned on and the rotation of the drum was observed as a function of time.

The results of this test are given in Fig. 8. While there is a minimum warm-up period required for the differential-transformer type recorder (recorders A and B), none is required for the electrical-contact type (recorder C). Figure 8 indicates that the drift—change in strain reading—is negligible after a 5-min warm-up period for recorder A and after 25 min for recorder B. The tests on recorders A and B were made with the cores of the differential transformers both on and off electrical center. The results show that the warm-up time is independent of the position of the core.

It is believed that the warm-up effect of the differential-transformer type of recorder is a function of the power dissipated in the transformer windings.

Dimensional Stability of the Chart Paper

To study the effects of relative humidity on the dimensional stability of the paper, three samples of chart paper from each recorder were tested in a constant humidity room. The relative humidity could be maintained at any desired value between 40 and 80 per cent. The grid of the chart paper was measured by comparison with a calibrated steel scale with the aid of two microscopes. Both microscopes permitted reading to 0.0001 in. Expansion and contraction of the chart paper due to changes in relative humidity were measured over a 7-in. length both with and across the grain. During these tests the ambient temperature was maintained at approximately 70 F.

The results of this test are given in Table III. It is seen that the error introduced by changes in relative humidity is significant. A 40 per cent change

TABLE III.—EXPANSION OF CHART PAPER DUE TO 40 PER CENT CHANGE IN RELATIVE HUMIDITY
(Temperature during test, 70 F)

Recorder	Expansion of Chart Paper in Terms of per cent of Length Measured	
	Along the Grain	Across the Grain
A	0.18	0.64
B	0.23	0.70
C	0.17	0.62

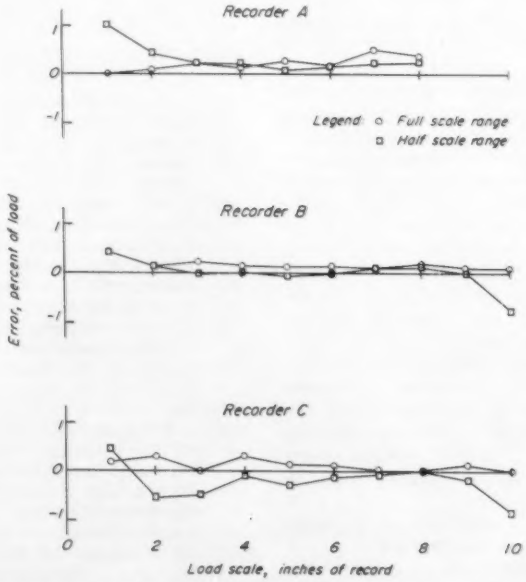


Fig. 9.—Calibration curves showing the performance of the load recording coordinate of three modern stress-strain recorders.

in relative humidity changes the length of the paper by 0.6 to 0.7 per cent in one direction (across the grain) of the paper. Since expansion of paper is proportional to the moisture content (92), the chart paper may expand as much as 1 per cent when subjected to changes in relative humidity as great as 60 per cent.

If paper is received in rolls, the grain is along the roll of the paper. Chart paper received in rolls has the load coordinate across the grain. However, when chart paper is received in sheets, either the printed load or strain coordinates may be across the grain. For the tests in this report, paper which had its load coordinate across the grain was used to minimize the effect of chart paper instability on the accuracy of the strain coordinate.

The uniformity of the grid of the chart paper was also measured. These measurements were made over a 1-in. length both with and across the grain. The grid along the strain coordinate of the chart paper is divided into 10 divisions per inch. Along the load coordinate the divisions are 10 or 12 to the inch. It was found that individual divisions deviated from the average of those measured by less than 0.004 in.

Calibration of the Load Coordinate

For the purposes of this test, the recorders were mounted on a testing machine of the same manufacture as the recorder. The recorder was turned off so that the recorder drum would not rotate. The chart paper was marked with the pen in a suitable manner as load intervals were observed on the testing machine indicator. Immediately following this, the distance between the pen marks was measured with the comparator. Since little time elapsed between making the record and measuring it, the effects resulting from changes in relative humidity were minimized.

The results of the calibration are given in Fig. 9. The errors in the recording of load compared to that indicated by the testing machine are less than 1 per cent, except for several isolated points at the lowest and highest load.

The testing machines used with the recorders all have provision for two ranges of load record on the recorders. In the full scale range, the load indicated by the full width of the chart paper is equivalent to full capacity of the range in use on the testing machine. For half scale, full chart width is equivalent to half of the capacity range on the testing machine.

It should be observed that to obtain the total error in load it would be necessary to add the testing machine error (93) to the error of the recorder. This total error may be more or less than the recorder error, depending upon the algebraic signs of both. The testing machine error was not included in Fig. 9 since only the recorder was being evaluated.

Conclusions

The stress-strain recorder used in metals testing is a highly developed instrument. The extensometers tested conform reasonably well with ASTM Method E 83 (79). The errors in strain indication, for the three recorders tested, on the 1000 and 500 extension-magnification ranges are essentially within the tolerances given for class B extensometers. The errors in strain indication for the recorders on the 250 and 125 extension-magnification ranges tend to exceed these tolerances for strains exceeding about 0.015. However, the mechanical properties of most metals can best be determined using extension magnifications of 1000 or 500. The results given may be typical of the performance of hundreds of recorders in use, but individual calibration of each recorder and extensometer is necessary to insure satisfactory performance. It is recommended that all stress-strain recorders in laboratory use be calibrated at periodic intervals. Portable extensometer calibrators, now available from several manufacturers, make possible a check of an extensometer and recorder combination in the field without serious loss in operating time.

References

Mechanical Testing of Metallic Materials

(1) R. Raring, J. A. Rinebolt, and W. J. Harris, Jr., "Effect of Alloying Elements on True-Stress, True-Strain Flow Curves of Pearlitic Steel," *Transactions*, Am. Inst. Mining and Metallurgical Engrs., Vol. 191, pp. 395–400 (1951).

(2) C. W. MacGregor, "Abstract of the True Stress-Strain Tension Test—Its Role in Modern Materials Testing, Parts I, II," *Journal of the Franklin Institute*, Vol. 238, Nos. 2 and 3, pp. 111–135, 159–176 (1944).

(3) C. Arbel, "Correlation of the Deep Drawing Qualities of a Material and its Tensile Test Results," *Engineers Digest*, Vol. 11, Sept., 1950, pp. 304–307.

(4) J. T. Lapsley Jr., R. C. Grassi, and E. G. Thomsen, "Correlation of Plastic Deformation During Metal Cutting with Tensile Properties of the Work Material," *Transactions*, Am. Soc. Mechanical Engrs., Vol. 72, Oct., 1950, pp. 979–986.

(5) Tentative Definitions of Terms Relating to Methods of Mechanical Testing (E 6–54 T), 1955 Book of ASTM Standards, Part 1, p. 1547; Part 2, p. 1201; Part 3, p. 1963; Part 4, p. 1341; Part 6, p. 1682; Part 7, p. 1617.

(6) H. B. Cronshaw, "Engineering and Mechanical Instruments," The Instrument Manual, United Trade Press, Ltd., London, pp. 25–43 (1949).

(7) F. B. Seely, "The Strength Features of the Tension Test," Symposium on Significance of Tension Test of Metals in Relation to Design, *Proceedings*, Am. Soc. Testing Mats., Vol. 40, pp. 535–550 (1940).

(8) J. B. Campbell, "What Tensile Properties of Metals Mean in Design," *Material and Methods*, Vol. 31, June, 1950, pp. 49–53.

(9) H. W. Gillett, "An Engineering Approach to the Selection, Evaluation and Specification of Metallic Materials," Reprinted from: *Steel*, Nov. 22, 1943, Feb. 14, 1944, 140 pages.

(10) E. P. Klier, "Russian Opinions on Evaluation of Metals by Mechanical Tests," *Metal Progress*, Vol. 57, March, 1950, pp. 358, 359, 372, 374, 375.

(11) Tentative Methods of Tension Testing of Metallic Materials (E 8–54 T), 1955 Book of ASTM Standards, Part 1, p. 1551; Part 2, p. 1246.

(12) Metals; Test Methods, Federal Test Method Standard No. 151, July 17, 1956, General Services Administration, Washington, D. C.

(13) F. G. Tatnall, "Speed of Testing," ASTM Bulletin, No. 161, Oct., 1949, p. 23-28 (TP 167).

(14) H. J. Maier, "Test Bar Results Compared with Tests on Components," *Metal Progress*, Vol. 58, July, 1950, pp. 72–75.

(15) H. A. Schwartz, and W. K. Bock, "Reproducibility of Results of Tension Tests on Specimens Prepared from Cast Steel Coupons," *Proceedings*, Am. Soc. Testing Mats., Vol. 50, pp. 1167–1175 (1950).

(16) B. A. Bilby, "The Theory of the Discontinuous Yield Point," *Sheet Metal Industries*, Vol. 27, Aug., 1950, pp. 707–718.

(17) E. R. Evans "An Investigation into the Relation of the Mechanical Properties of Ring Test Pieces to Those of Test Bars," *Journal of Research and Development*, British Cast Iron Research Assn., Vol. 3, June, 1950, pp. 421–440.

(18) W. Spath, "Performance and Evaluation of the Static Test" (in German), *Schweizer Archiv für angewandte Wissenschaft und Technik*, Vol. 17, June, 1951, pp. 177–181.

(19) H. Vosskuhler, "High-Temperature Tensile Testing of Aluminum Alloys" (in German), *Zeitschrift für Metallkunde*, Vol. 41, May, 1950, pp. 144–151.

(20) E. Siebel, "Materials Testing and Strength Research in Germany in the Years 1939–1949" (in German), *Schweizer Archiv für angewandte Wissenschaft und Technik*, Vol. 16, April, 1950, pp. 97–114.

(21) J. O. Jones, "High Magnification Stress-Strain Charts," *Machinery* (London), Vol. 71, No. 1828, Nov. 6, 1947, pp. 513–515.

Development of Stress-Strain Recorders Used in the Testing of Metallic Materials

(22) A. Martens, Handbook of Testing Materials, Vols. I, II, John Wiley and Sons, Inc., New York, N. Y., 622 pp., 240 pages (1899).

(23) J. A. Ewing, "The Strength of Materials," Second Edition, Cambridge University Press, London, 248 pages (1906).

(24) M. Hetenyi, Handbook of Experimental Stress Analysis, John Wiley and Sons, Inc., New York, N. Y., 1077 pages (1950).

(25) R. G. Batson and J. H. Hyde, "Mechanical Testing—Testing of Materials of Construction," Vol. I, Chapman & Hall, Ltd., London, 465 pages (1931).

(26) W. K. Hatt, "A Laboratory Course in Testing Materials of Construction," *Proceedings*, Am. Soc. Testing Mats., Vol. 5, pp. 234–253 (1905).

(27) H. F. Moore, "An Autographic Recorder for Rapid Tension Testing," *Proceedings*, Am. Soc. Testing Mats., Vol. 8, pp. 653–657 (1908).

(28) F. C. Turner, "A Mechanical Autographic Extensometer," *Engineering*, Vol. 122, No. 3172, Oct. 29, 1926, pp. 525, 526.

(29) R. L. Kenyon and R. S. Burns, "Autographic Stress-Strain Curves of Deep-Drawing Sheets," *Transactions*, Am. Soc. Steel Treating, pp. 577–612 (1933).

(30) A. T. King, "Engineering Inspection Practice," Chemical Publishing Co., Inc., Brooklyn, N. Y., 242 pages (1944).

(31) N. A. Shaposhnikov, Mechanical Testing of Metals (Mekhanicheskie ispi'taniya metallov) (in Russian), *Gosudarstoennyi Nauchnyi-tekhnichno Izdat*, Moscow-Leningrad, Mashinostroit, Lit., 383 pages (1951).

(32) T. Mitsutaro, R. Nazagawa and S. Saito, "The Stress-Strain Diagram of Time-Piece Springs" (in Japanese), *Journal Mechanical Laboratory*, Vol. 5, Oct. 1951, pp. 247–251.

(33) K. Ruhl, "Neuere Hilfsmittel der Festigkeitsforschung," *Technik*, Vol. 3, No. 7, July, 1948, pp. 301–304.

(34) T. D. Lynch, "Elastic Limit," *Proceedings*, Am. Soc. Testing Mats., Vol. 15, Part II, pp. 415–436 (1915).

(35) H. F. Moore, "Rapid Semi-Autographic Tests for Determining the Proportional Limit," *Proceedings*, Am. Soc. Testing Mats., Vol. 17, Part II, pp. 589–598 (1917).

(36) J. L. Jones and C. H. Marshall, "Sumner Elastic-Limit Recorder," *Proceedings*, Am. Soc. Testing Mats., Vol. 81, Part II, pp. 478-483, (1918).

(37) C. H. Marshall, "Improved Elastic-Limit Recorder," *Proceedings*, Am. Soc. Testing Mats., Vol. 20, Part II, pp. 361–365 (1920).

(38) J. H. Smith, "Rate of Elongation in Tension Tests," *Proceedings*, Am. Soc. Testing Mats., Vol. 27, Part II, pp. 507–521 (1927).

(39) R. L. Templin, "An Automatic Autographic Extensometer for Use in Tension Tests of Materials," *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part II, pp. 783–792 (1932).

(40) A. Binns, "Autographic Load-Strain Recorders," *Journal Institute of Metals*, Vol. 81, Feb., 1953, pp. 166–168.

(41) J. P. Shamberger, "A Magnetic Strain Gage," *Proceedings*, Am. Soc. Testing Mats., Vol. 30, Part II, pp. 1041–1047 (1930).

(42) J. Sivertsen, "Variable Inductance Device," U. S. Patent No. 2,179,058, Nov. 7, 1939 (applied for March 27, 1936).

(43) A. G. Boggis, "Design of Differential Transformer Displacement Gauges," *Proceedings*, Soc. Experimental Stress Analysis, Vol. 9, No. 2, pp. 171–184 (1952).

(44) W. D. MacGeorge, "Motion Recording Apparatus," U. S. Patent No. 2,451,757, Oct. 19, 1948 (applied for July 18, 1944).

(45) F. G. Tatnall, "Testing Today and Tomorrow," *Metal Progress*, Vol. 61, Jan., 1952, pp. 64–67.

(46) J. R. Low, Jr., and F. Garofalo, "Precision Determination of Stress-Strain Curves in the Plastic Range," *Proceedings*, Soc. Experimental Stress Analysis, Vol. 4, No. 2, pp. 16–24 (1947).

(47) E. Perrin, "Adaptation to Field Use of Deformation-Recording Apparatus" (in French), *Annales, Inst. Technique Batiment et Travaux Publics*, No. 126, March-Apr., 1950, pp. 1–15.

(48) E. N. Da C. Andrade and A. J. Kennedy, "An Automatic Recording Apparatus for the Study of Flow and Recovery in Metals," *Proceedings*, Physical Soc. (London), Vol. 62, Section B, Nov. 1, 1949, pp. 669–675.

Stress-Strain Recorders Used in the Testing of Rubber, Textiles, etc.

(49) G. S. Burr, W. J. Gailus, J. O. Silvey, S. Yurenka, and G. H. Dietz, "Universal Plastics Testing Machine," *Proceedings*, Am. Soc. Testing Mats., Vol. 47, pp. 1030–1039 (1947).

(50) H. Hindman and G. S. Burr, "The Instron Tensile Tester," *Transactions*, Am. Soc. Mechanical Engrs., Vol. 71, Oct., 1949, pp. 789–796.

(51) H. F. Schiefer, "Measurement and Elimination of Inertia Effects in Textile Testing Equipment by Means of Electric Strain Gages," ASTM BULLETIN, No. 150, Jan., 1948, pp. 43–45 (TP15).

(52) J. W. Ballou, "A Stress-Strain Tester for Textiles Employing a Magnetic Strain Gage," ASTM BULLETIN, No. 150, Jan. 1948, pp. 38–42 (TP10).

(53) C. H. Reichardt, H. Schaevitz, and J. H. Dillon, "Stress-Strain-Time Apparatus for Fibre Testing," *Review Scientific Instruments*, Vol. 20, July, 1949, pp. 509–516.

(54) J. R. McLoughlin, "A Recording Stress Relaxometer, *Review Scientific Instruments*," Vol. 23, No. 9, Sept., 1952, pp. 459–462.

(55) R. S. Stein and H. Schaevitz, "An Autographic Stress Relaxometer," *Review Scientific Instruments*, Vol. 19, No. 12, Dec., 1948, pp. 835–839.

(56) L. J. Markwardt and J. A. Liska, "Speed of Testing on Wood: Factors in Its Control and Its Effect on Strength," Symposium on Speed of Testing, *Proceedings*, Am. Soc. Testing Mats., Vol. 48, pp. 1139–1159 (1948).

(57) C. W. Harris, "A Simple Autographic Stress-Strain Tester," *Review Scientific Instruments*," Vol. 16, No. 1, Jan., 1945, pp. 5, 6.

(58) F. H. Muller, "Instrumentation for the Determination of Stress-Strain Diagrams of Single Fibers Under Extreme Conditions" (in German), *Kolloid-Zeitschrift*, Vol. 112, Feb., 1949, pp. 84–91.

(59) F. Nistica, B. S. Spraque, and R. W. Work, "A High-Speed Yarn Tensiometer," *Textile Research Journal*, Vol. 22, No. 2, Feb., 1952, pp. 99–110.

(60) S. P. Steward, "Measurement of Tensile Strength of Suture Materials," *Journal of Scientific Instruments*, Vol. 28, No. 4, Apr., 1951, pp. 114–115.

(61) J. A. Scarlett and J. A. Robertson, "An Automatic Apparatus for Testing Refractories Under Tensile and Compressive Loads at High Temperatures," *Journal*, Am. Ceramic Soc., Vol. 34, No. 11, Nov., 1951, pp. 348–353.

Special Recorders, Accessory Devices and Problems Relating to Stress-Strain Recording

(62) J. A. Miller, "Stress-Strain and Elongation Graphs for Alclad Aluminum-Alloy 75-S-T Sheet," Nat. Advisory Committe Aeronautics, TN No. 1385, Nov., 1947, 36 pages.

(63) H. La Tour and D. S. Wolford, "Single-Strip Compression Test for Sheet Materials," *Proceedings*, Am. Soc. Testing Mats., Vol. 45, pp. 671–691 (1945).

(64) B. Bergqvist, "Apparatus for Recording the Compressive Stress-Strain Curve for Thin Material Coupons at Large Strains," *FFA Report No. 39*, Aeronautical Research Institute of Sweden, 31 pages (1951) (TIP No. U 20269).

(65) D. E. Driscoll, "Mechanical Tests of Bend Test Device for Autographic Recording of Load-Deflection Diagrams," *Report No. WAL 110/14*, Watertown Arsenal Lab., June 3, 1948, 6 pages (TIP No. U 52622).

(66) C. S. Smith, "Proportional Limit Tests on Copper Alloys," *Proceedings*, Am. Soc. Testing Mats., Vol. 40, pp. 864–884 (1940).

(67) C. W. MacGregor, "The Tension Test," *Proceedings*, Am. Soc. Testing Mats., Vol. 40, pp. 508–534 (1940).

(68) H. I. Fusfeld, and J. C. Feder, "Study of Deformation at High Strain Rates Using High Speed Motion Pictures," ASTM BULLETIN, No. 170, Dec., 1950, pp. 75–79 (TP301).

(69) L. Gillemot, "Measuring Devices for Investigation of True Stresses" (in German), *Acta Technica Academiae Scientiarum Hungaricae*, Budapest, Vol. 1, No. 3, pp. 191–197 (1951).

(70) A. G. H. Anderson, "Stress-Strain Time Phenomena in Mechanical Testing," *Report No. ORNL-1114*, Atomic Energy Commission, 93 pages (1952).

(71) K. K. Likharev, "Technique of Plotting Diagrams of True Stresses" (in Russian), Zavodskaya Laboratoriya, Vol. 15, Nov., 1949, pp. 1343–1347.

(72) E. L. Bartholomew, Jr., K. J. Krystyan, D. A. J. Millar, and J. Wulff, "A Machine for Tensile Testing at Controlled Temperatures and Constant True Strain Rates," *Review Scientific Instruments*, Vol. 24, No. 3, March, 1953, pp. 196–202.

(73) R. J. Flynn and M. Stoll, "An Automatic Recording Extensometer System," *PIBAL Report No. 122*, Polytechnic Institute of Brooklyn, June 2, 1948, 3 pp. (TIP No. U 6252).

(74) C. D. Nail and E. R. Parker, "An Inexpensive Automatic Dial Gage Strain Recorder," *Technical Report No. 3*, Univ. of California, Berkeley, Jan., 1950, 13 pp. (TIP No. U 9394).

(75) P. R. Weaver, "An Optical Strain Gage for Use at Elevated Temperatures," *Proceedings*, Soc. Exptl. Stress Anal., Vol. 9, No. 1, pp. 159–162 (1952).

(76) H. C. Roberts, "Notes on the Application of SR-4 Strain Gages," *Technical Report*, Univ. Illinois, July 20, 1949, 19 pages (TIP No. U 11586).

(77) R. Ono and T. Itakura, "Strain Meter Using Parallel Plate Condenser," *Faculty Engineering Memoirs*, Hokkaido Imperial Univ., Vol. 6, No. 2, Feb., 1941, pp. 99–111.

(78) "Variable-Resistance Spring Transducer," *Journal Applied Physics*, Vol. 19, No. 10, Oct., 1948, p. 972.

Calibration Apparatus and Performance Characteristics of Strain Measuring Devices

(79) Tentative Method of Verification and Classification of Extensometers (E 83–52 T), 1955 Book of ASTM Standards, Part 1, p. 1678; Part 2, p. 1383; Part 6, p. 1648.

(80) C. E. Phillips, "A Review of Some Strain Measuring Devices," Measurement of Stress and Strain in Solids, Institute of Physics, University Press, Cambridge, pp. 66–72 (1948).

(81) A. H. Stang and L. R. Sweetman, "An Extensometer Comparator," *Journal of Research*, Nat. Bureau of Standards, Vol. 15, No. 3, pp. 199–203, RP 822 (1935).

(82) C. E. Phillips, "Apparatus for Calibration of Mirror Extensometers of Marten Type," *Journal of Scientific Instruments*, Vol. 16, No. 3, March, 1939, pp. 87–90.

(83) J. H. Rondeel, W. K. G. Floor, and A. C. de Kock, "Development and Testing of an Apparatus for Calibrating Extensometers and Some Preliminary Calibrations" (in Dutch), *Report S. 359*, Nat. Aeronautical Research Inst., Amsterdam, Aug., 1949, 26 pages.

(84) R. L. Templin, "The Calibration of Extensometers," *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part II, pp. 714–727 (1928).

(85) D. A. Morelli, "Calibrator for Strain Gages and Extensometers," *Commonwealth Engineer*, Vol. 29, No. 12, July 1, 1942, pp. 290–291.

(86) R. Hiltscher, "A Practical Lateral-Extensometer for Determination of the Sum of Principle Stresses" (in German), *Kungliza Tekniska Hogskolans Handlingar*, (*Transactions*, Royal Institute of Technology (Stockholm)), No. 42, 22 pages (1950).

(87) W. C. Aber and F. M. Howell, "A Method of Calibrating Extensometers," ASTM Bulletin, No. 155, Dec., 1948, p. 33-35 (TP 241).

(88) B. L. Wilson, "Characteristics of the Tuckerman Strain Gage," *Proceedings*, Am. Soc. Testing Mats., Vol. 44, pp. 1017–1026 (1944).

(89) C. Pulfrich, "Über einen Interferenzmessapparat," *Zeitschrift Instrumentenkunde*, Vol. 18, p. 261 (1898).

(90) "Interference-Fringe Counter," *Electronic Equipment*, Vol. 3, No. 11, Nov., 1955, pp. 6–7.

(91) R. L. Templin, "Some Factors Affecting Strain Measurements in Tests of Metals," *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part II, pp. 182–201 (1934).

(92) Robert F. Reed, "What the Lithographer Should Know About Paper," *Technical Bulletin*, Lithographic Technical Foundation, Inc., New York, N. Y., No. 8, 101 pages (1949).

(93) Tentative Method of Verification of Testing Machines (E 4–55 T), 1955 Book of ASTM Standards, Part 1, p. 1541; Part 2, p. 1195; Part 3, p. 1910; Part 4, p. 1288; Part 6, p. 1636; Part 7, p. 52.

DISCUSSION

Mr. L. J. Markwardt.[1]—I notice you point out that one source of error results from dimension changes of the recording paper due to changes of atmospheric moisture or humidity. I should like to inquire if this is a serious problem and whether some improvement of the recorder papers is needed to reduce that error. I mention this because I am sure that more dimensionally stable papers can be developed if required.

Mr. R. R. Bouche (*author*).—Some error in the stress-strain diagram will result if the moisture content of the paper changes between the time when the grid was printed on the paper and the time when the tension test is performed. Our tests showed that a 40 per cent change in relative humidity caused a dimensional change of approximately 0.65 per cent across the grain and 0.2 per cent along the grain of the paper. This means 0.65 per cent error for the load coordinate and 0.2 per cent for the strain coordinate if the paper is printed in rolls. If printed in sheet form the 0.65 per cent error may be on the strain coordinate. For a strain value of 0.005, this corresponds to a strain error of 0.00003. Ordinarily this would not be a serious source of error. However, since the cost of the chart paper is small compared to other costs involved in a tension test, many testing laboratories would probably be willing to buy special high-stability chart paper if it were available.

[1] ASTM Past President, assistant director, U. S. Forest Products Lab., Madison, Wis.

A Stress Computer for the SR-4 Testing Machine

By R. D. BEHR and J. A. GUSACK

A device to produce stress-strain curves directly

MANY design properties of materials can be determined from stress-strain curves. However, load-strain curves rather than stress-strain curves are obtained from most testing machines. Although it is possible to replot stress-strain curves from load-strain curves, this procedure is time-consuming and may introduce human errors.

The Metallurgical Laboratory of The Dow Chemical Co. realized the potential advantages of a testing machine equipped to plot stress-strain curves directly. It was thought that an accessory could be designed that would vary the load-recording characteristics of a standard testing machine to accommodate various specimen areas. Since, in general, it is easier to apply a variable control to an electrical load signal than to a mechanical load signal, the Model FGT Baldwin-Emery Universal Testing Machine, which uses an electrical signal, was selected as the base on which to carry out development of a stress computer. The Baldwin Co. supplied a computer in which specimen area was introduced by a potentiometer setting. Experience showed that the Baldwin computer could be made more convenient by providing a direct-reading area-input dial and a second stress range. This paper describes the principles of operation and construction of the modified computer.

Principle of Operation

The standard testing machine employs a null-balance system wherein the load-cell signal is balanced electrically by the displacement of the dial indicator. The amount of indicator displacement neces-

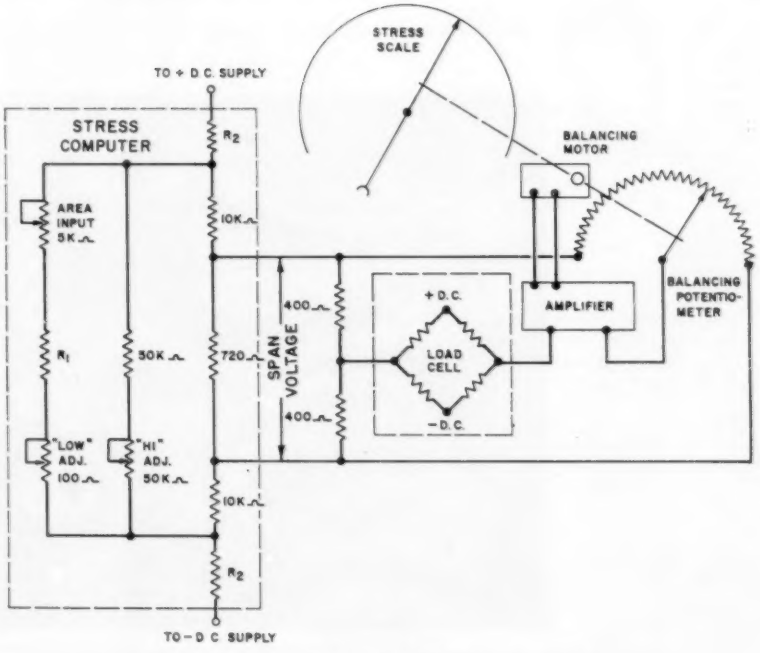


Fig. 1.—Schematic drawing of the stress computer.

R. DOUGLAS BEHR and JAMES A. GUSACK, research and development engineers, The Dow Chemical Co., Midland, Mich., have been working on mechanical testing and design of magnesium alloys since 1954.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

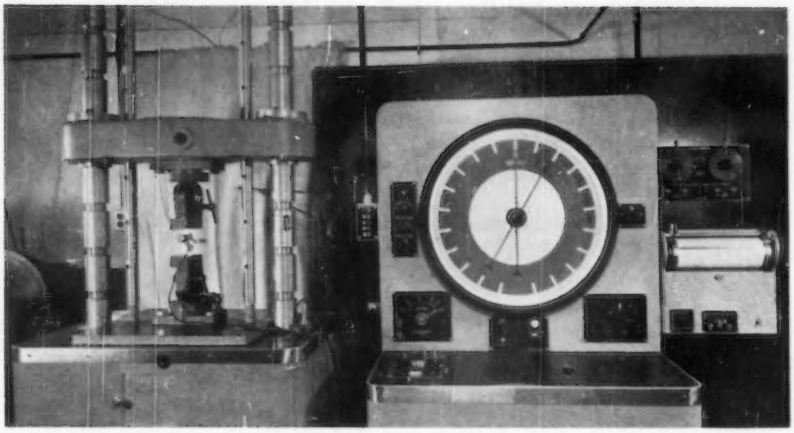


Fig. 2.—Testing machine with the modified stress computer.

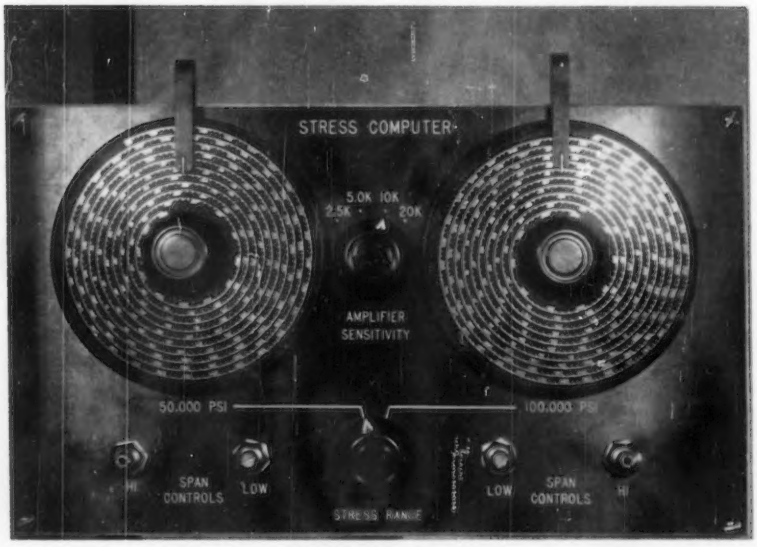


Fig. 3.—Stress computer.

sary to balance a given signal is controlled by a load-range switch, so that a full-scale dial reading corresponds to a selected value of maximum load. Ordinarily, the load-range switch will have, perhaps, four positions, for four different values of maximum load at full-scale deflection. If an infinitely variable, rather than a "stepped," control is used in the system, however, it is possible to have a given indicator displacement correspond to *any* desired load within the capacity of the machine. Further, if the control is calibrated in terms of specimen area, then by properly locating this control, the indicator dial can be made to read directly in terms of stress. This is the principle on which the design of the stress computer has been developed.

A schematic drawing of the stress computer is shown in Fig. 1. The circuit is fundamentally an infinitely variable voltage divider with provisions for varying a span voltage by the setting of the 5000-ohm area-input potentiometer. The span voltage controls the amount of indicator displacement necessary to balance a given load signal. Values of resistors R_1 and R_2 are determined for the specific range of specimen areas and full-scale stress desired.

The modified computer is shown in Fig. 2 mounted above the stress-strain recorder at the right of the testing machine. A close-up view of the computer is shown in Fig. 3. In operation, full-scale stress is selected by the stress-range switch, and specimen area is directly fed into the computer by the position of the appropriate area-selector dial. The amplifier-sensitivity switch provides controlled damping to eliminate dial-indicator oscillation. High and low span controls allow adjustments of the span voltages at both ends of the specimen-area range for precise calibration. A stress-strain curve of the magnesium-base extrusion alloy ZK60A-T5 produced with the use of the computer, is shown in Fig. 4.

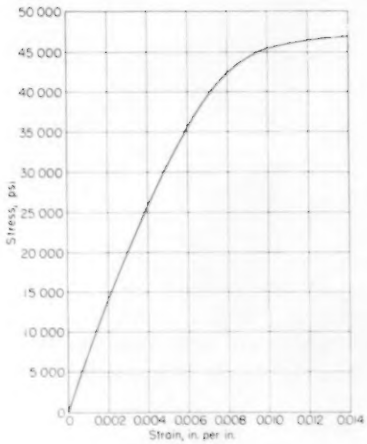


Fig. 4.—Stress-strain curve of the magnesium alloy ZK60A-T5.

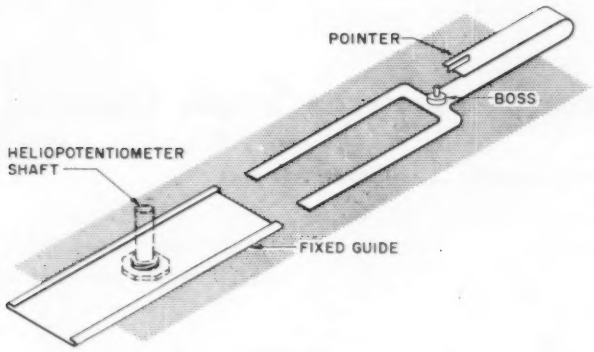


Fig. 5.—Detail of pointer construction.

Details of Design

The direct-reading area-selector dials shown in Fig. 3 are mounted on the shafts of the 5000 ohm ten-turn heliopotentiometers. On the face of each dial an area scale, determined by direct calibration, is oriented along a spiral to accommodate the multirevolutions of the potentiometer. Rotation of the direct-reading dial produces vertical translation of a pointer so that the tip of the pointer traces the spiral on the dial face.

Both the pointer and guide in which it slides are simple in construction, as seen in Fig. 5. The guide allows translation but prevents rotation of the pointer. Movement of the pointer is controlled by a nylon boss, cemented on the pointer, which rides in a spiral groove machined in the back of the dial.

Area scales were photographically transferred from oversize drawings to the direct-reading dials of magnesium alloy by the Dow etch process. The etching process left the numbers and graduations in relief on the dial faces. Wear resistance in the machined grooves on the backs of the dials was provided by a protective chromium plating. To provide contrast, a black wrinkle finish was applied to the etched faces of the dials.

Calibration of the area-selector dials was accomplished by first measuring the loads required to produce full-scale stress reading with the dials set at 90-deg intervals of rotation; a total of 41 determinations for each dial. Area was calculated from each load and plotted against dial setting on large sheets of graph paper. Based on nonlinear curves drawn through these points, the setting of the dials was determined for each major graduation of the area scale (multiples of 0.001 sq in.). Minor divisions were established at area intervals of 0.0002 sq in. by linear interpolation.

Subsequent to the construction of the dials, calibration was checked at ten settings of each area-selector dial. In general, accuracy was best at the high end of the area scale. The largest error, 0.53 per cent, was measured at the smallest area checked, 0.040 sq in., and the average percentage error was found to be 0.11 per cent. These values are within the normal precision of measurement of test specimens.

Circuit Design

The basic computer circuit shown in Fig. 1 can be designed to accommodate a desired range of specimen areas and full-scale stress. The problem is to determine the values of the resistors R_1 and R_2 for the desired conditions.

Since the computer is fundamentally a voltage divider, the span voltage can be controlled by varying the setting of the 5000-ohm area-input potentiometer, and the values of the fixed resistors R_1 and R_2. However, R_1 and R_2 must be determined so that when the area-input potentiometer is set at either end of the rotor travel, corresponding to one or the other end of the specimen-area range, the desired full-scale stress reading will be developed by the correct load for these specimen areas. Intermediate area settings can then be related to area-input potentiometer settings by calibration.

Approximate design equations have been derived relating values of the resistors R_1 and R_2 to the desired range of area and full-scale stress. The equations are:

$$R_1 \approx 10{,}400 \left[1 + \frac{0.73\,A\,(1 - 0.000018B)}{(B - A)}\right]^{1/2} - 10{,}450$$

$$R_2 \approx \frac{7900\,(R_1 + 50)}{15{,}850 + R_1}\left[\frac{55{,}500}{A} - 1\right]$$

where:

A = minimum area × full-scale stress, lb, and
B = maximum area × full-scale stress, lb.

Summary

The stress computer has been found to be a valuable and very workable accessory to the basic testing machine. In addition to the time-saving accomplished by its use, the potential errors of the operator in selecting load ranges and replotting stress-strain curves have been significantly reduced.

A True Stress–True Strain Computer

By THOMAS S. DeSISTO and DAVID E. DRISCOLL

An accurate autographic true stress–true strain test can be conducted in 10 per cent of the time required to do it manually

THE TEST most commonly used to determine the mechanical properties of materials has been the tension test. The most important aspects of the tension test (yield and tensile strengths) are determined by dividing the instantaneous load by the original cross-sectional area. However, as soon as yielding begins, the cross-sectional area begins to decrease, and yield and tensile determinations become less exact.

Recognizing the importance of true stress – true strain determinations, investigators began to devise various means of obtaining instantaneous diameter or elongation measurements. Once equipped with these data and corresponding load measurements, they could construct a true stress–true strain curve. However, the time involved in conducting the tests (computing true stress – true strain and constructing the curve) was excessive.

Having obtained an autographic device for diameter measurement as part of an autographic recorder for true stress *versus* elongation,[1] the Watertown Arsenal Laboratories again contracted with United Shoe Machinery Corp. to construct a computer which could utilize the diameters obtained from the diameter measurement unit and determine and record true stress – true strain values continuously.

The true stress – true strain computer shown in Fig. 1 consists of a diameter measurement unit, a computer, and a Baldwin MD2 recorder. Diameter and load data are transmitted to the

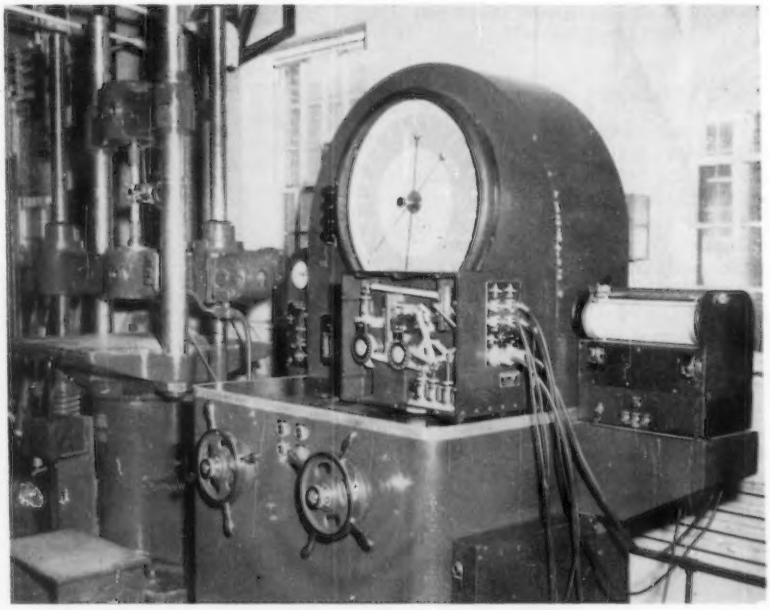


Fig. 1.—True stress–true strain setup.

At left is the diameter measurement unit; center, the computer; right, the recorder.

THOMAS S. DeSISTO, chief of the Materials Properties Section at the Watertown Arsenal Laboratories, Watertown, Mass., has, since 1949, been concerned with mechanical testing techniques and low temperature mechanical properties.

DAVID E. DRISCOLL, chief of the Mechanical Metallurgy Branch at the Watertown Arsenal Laboratories, Watertown, Mass., has, since 1930, been engaged in research, development, and testing of ferrous and nonferrous metals for Ordnance application, with special emphasis in the impact field. He is a member of ASTM Committees E-1 on Methods of Testing, and E-9 on Fatigue.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] D. E. Driscoll and T. S. DeSisto, "True Stress *versus* Elongation Recorder," *Report No. 111/23*, Watertown Arsenal Laboratory, July, 1955.

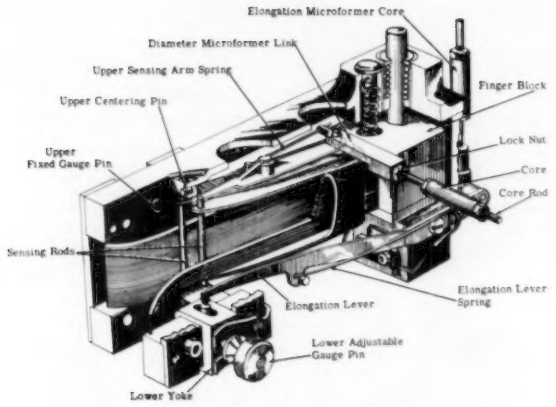


Fig. 2.—Measurement unit, cutaway view.

computer by microformers (miniature linear-differential type) which, in turn, resolve these data in terms of true stress – true strain and transmit the results by microformers to the recorder.

Basic Factors

The diameter-measuring unit was designed on the assumption that the specimen cross-section remains approximately circular throughout the test.

The term *true stress* as used here represents average stress across the mimimum measured cross-section according to the equation:

$$S = \frac{4L}{\pi D^2} \quad \ldots\ldots\ldots\ldots (1)$$

where:

S = true stress, psi,
L = applied load, lb, and
D = minimum neck diameter, in.

Assuming that the volume of the test specimen being deformed remains constant throughout the test:

$$\text{True strain} = 2 \log_e \frac{d_0}{d} \quad \ldots\ldots (2)$$

where:

d_0 = original diameter, and
d = instantaneous diameter.

The Computer Described

Diameter-Measurement Unit

The diameter-measurement unit (Fig. 2) consists of two groups of fingers which conform to the profiles of opposite sides of the specimen. They are held firmly by spring pressure and are free to move in with the neck as elongation takes place. The fingers, 0.070 in. wide and 0.018 in. thick, are cantilever beams of approximately rectangular cross-section. The fingers are stacked tightly together, 40 to a group, and are free to move relative to each other at the sensing end. Each group is pivoted to the finger block, with aluminum foil spacers between each of the fingers. The foil serves to prevent the heavy clamping pressure from extending to the cantilevered portion of the fingers. The stack is 0.75 in. high and will detect the minimum diameter of the specimen within this region.

The finger block serves as a clamp for the fingers and as a support for the related equipment. The assembly is counterbalanced by means of a tension spring to allow the fingers to "float" with the motion of the neck.

The minimum diameter is determined by the sensing arms. The movement of both arms is aided by a straight lever which is linked to the diameter microformer. The resultant electrical impulses are sent to the computer.

Computer

In principle, the computer (Fig. 3) is a straight lever with a movable

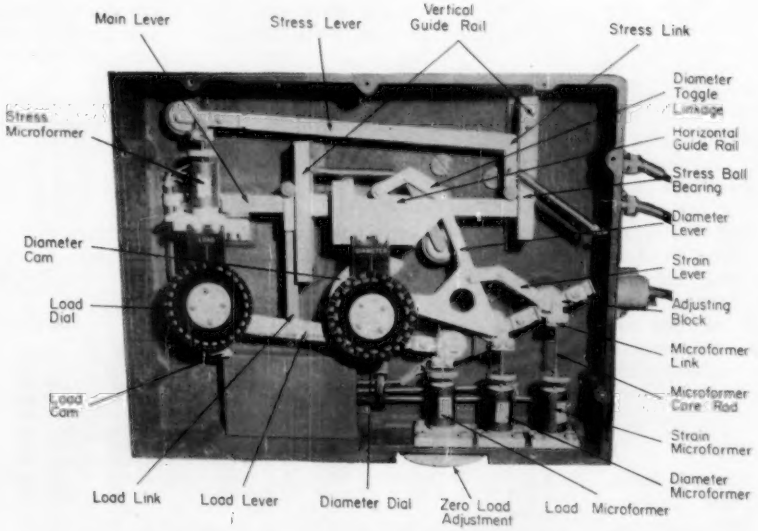


Fig. 3.—True stress–true strain computer.

fulcrum between the ends so that a changing lever ratio can be obtained. One end of the lever is fixed according to the load data, and the resultant position of the other end represents the true stress. The fulcrum is set as a function of the minimum diameter, according to the equation:

$$\frac{X}{L - X} = K\left(\frac{D}{0.357}\right)^2 \quad \ldots\ldots(3)$$

where:

L = effective length of lever (7.500 in.),
X = distance of fulcrum from load end, in.,
K = appropriate scale factor (2), and
D = minimum diameter which corresponds with distance X, in.

The true stress data are transferred to the recorder in the form of an electrical signal. The minimum-diameter data are converted by a simple computer linkage system to true strain data, which, in turn, are transferred to the recorder as an electrical signal.

Main Lever

Data from the diameter-measurement unit act on the diameter linkage (see Fig. 3), causing the main lever, with its linkage, to shift horizontally. The fulcrum, which is set on ball bearings, rides along the horizontal rails. The lever is kept in alignment by passing between both pairs of vertical rails. The back lash in the various linkages is kept to a minimum by three sets of tension springs.

Microformers

Four microformers are used, one each for load, diameter, true stress, and true strain. The zero position of the cores can be adjusted and maintained by the use of a lock nut to secure the rod once it is in position.

Load Mechanism

Data from the testing machine's load microformers act on the load mechanism which positions the computer's load microformer core. The load motor rotates the uniform-rise cam and load dial, which causes the load lever to raise or lower the microformer core. The motion of the cam causes the load lever to raise or lower the load link and ball bearings. This motion causes the ball bearings to position the main lever with the testing machine's load data.

Diameter Mechanism

The diameter mechanism (a uniform-raise cam) positions the diameter microformer core and the main lever. The diameter dial is calibrated to read specimen diameter, with markings that correspond to uniform increments of the microformer core position.

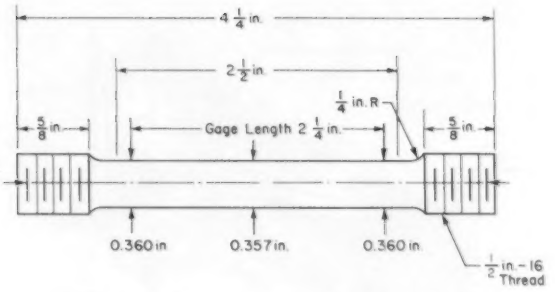


Fig. 4.—True stress–true strain specimen.

True Stress Mechanism

The main lever (see Fig. 3) positions the true stress lever and ball bearings in conjunction with the guide rails. The centers of the main fulcrum, the load, and the ball bearings of the true stress lever always remain on a straight line. This straight line is the computing lever. The core of the true stress microformer is positioned by the computed true stress.

True Strain Mechanism

The link and microformer core of the true strain lever (see Fig. 3) are fixed by the diameter lever. The linkage is arranged to convert diameter data into true strain data.

Test Procedure

With the specimen threaded into the holders and the diameter-measurement unit affixed to the specimen, test procedure is as follows:

1. Connect power lines and turn on the motor switches of the computer and recorder.
2. Read the computer diameter dial to see whether it conforms with actual diameter measurement.
3. With the testing machine at a minor load setting, check to see whether the computer's load dial conforms.
4. Set recorder to read zero true stress and zero true strain.

When all test equipment has been checked, the tension test is conducted in the usual manner. To allow the servo motors to function properly, the maximum load rate should not exceed 30,000 lb per min. The servos can follow a maximum diameter rate to 0.30 in. per min.

Test Results

To determine the versatility and accuracy of the device, modified specimens 0.357 in. in diameter (Fig. 4) were machined from AISI 4340 steel.

Since both true stress and true strain are functions of diameter measurements and the accuracy of the diameter-measurement unit of the true stress – true strain computer has already been established,[1] the computer need only be checked.

To check the accuracy of the computer, simultaneous diameter and load measurements were recorded on the curve at various diameter reductions (Fig. 5). The data presented in Table I are the average values of five specimens tested. The results show less

TABLE I.—AVERAGE VALUES OF FIVE SPECIMENS OF AISI 4340 STEEL.

Diameter	True Strain, psi		Diameter[a] Variation	Deviation, per cent	True Stress, psi		Deviation, per cent
	Calculated	Recorded			Calculated	Recorded	
0.350	0.0384	0.0382	0.00004	−0.52	82.20	83.00	+0.97
0.345	0.0671	0.0657	0.00020	−2.08	96.00	97.00	+1.04
0.340	0.0962	0.0961	0.00002	−0.10	103.00	104.00	+0.97
0.335	0.1260	0.1272	0.00020	+0.95	108.00	109.00	+0.93
0.330	0.1562	0.1572	0.00020	+0.64	111.00	112.00	+0.89
0.325	0.1866	0.1894	0.00050	+1.50	114.50	115.50	+0.87
0.320	0.2175	0.2206	0.00050	+1.40	117.50	118.00	+0.43
0.315	0.2493	0.2520	0.00040	+1.08	121.00	121.00	+0.00
0.310	0.2803	0.2830	0.00040	+0.96	123.00	123.50	+0.40
0.305	0.3123	0.3153	0.00050	+0.96	124.75	126.00	+1.00
Average				1.02			0.75

[a] Diameter change necessary to reflect difference between calculated and recorded true strain.

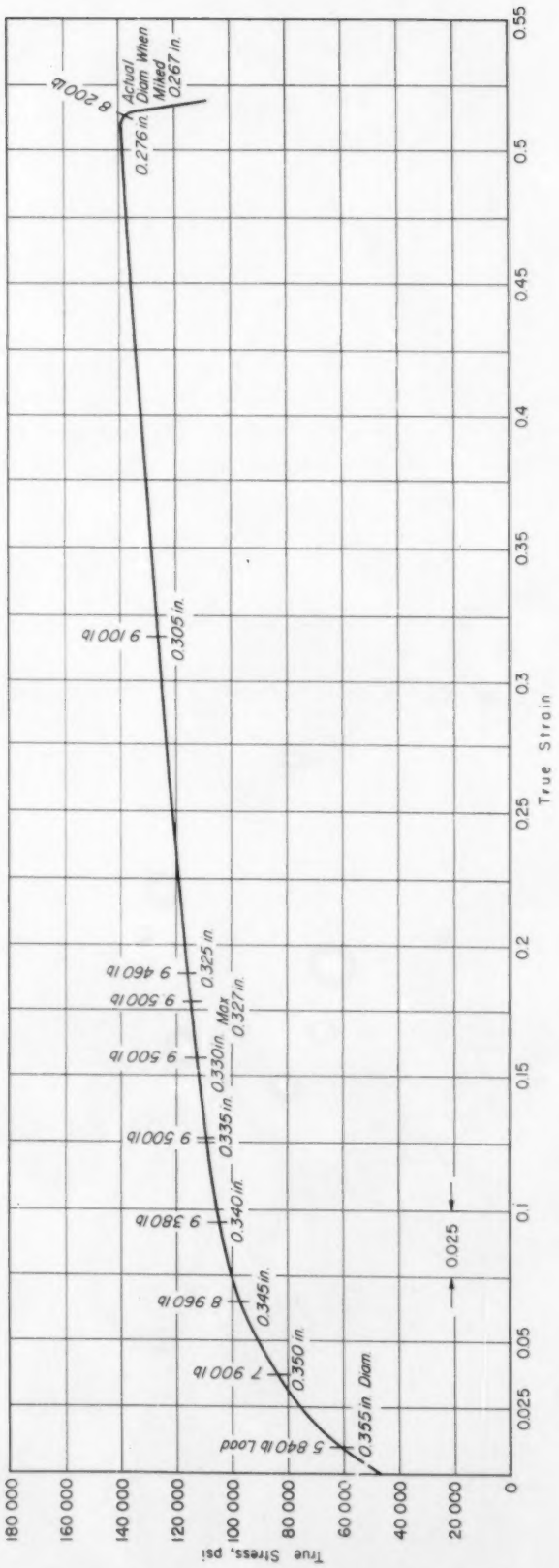


Fig. 5.—Typical true stress–true strain curve.

than 1 per cent deviation between calculated and recorded values.

The previous method used at the Watertown Arsenal Laboratories for obtaining true stress – true strain data required the services of two men. Instantaneous diameter measurements obtained with a hand or dial micrometer, and testing machine load data were called aloud to the technician who recorded and plotted the data. True stress – true strain data were calculated and the curves constructed manually. The entire operation required approximately 1½ to 2 hr at conventional strain rates. Using the true stress – true strain computer, the time required to test one specimen, including setup time, is approximately 10 min.

While conducting true stress – true strain tests, particularly those which involve varying strain rates, the chance of human error is high. The machine operator and the technician who measures diameter changes, hastily calling load and diameter data to the technician who is recording data, are likely sources of human error. This, on the other hand, is not encountered with the true stress-true strain computer.

Conclusions

1. The true stress – true strain computer is an accurate device for the autographic recording of true stress – true strain data.
2. An autographic true stress – true strain test can be conducted in approximately 10 per cent of the time required to conduct the test and construct the curve manually.
3. By eliminating manual measurements and calculations, human error is minimized.

A High-Speed Tension Testing Machine

By S. STRELLA, H. SIGLER, M. CHMURA, and B. HOLMAN

The tester will fracture a test specimen in the loading time range of 5 to 40 milliseconds, giving the stress-strain behavior of the specimen. The loading mechanism of the tester is of a construction that easily permits the testing of specimens of various shape and materials

It is a well-known fact that the tensile properties of materials are dependent on the loading rate to which the material is subjected. For example, a steel tested in our laboratory had a maximum tensile strength of 95,000 psi when tested at a static rate of loading, whereas, when tested at a high rate (about ten milliseconds), the strength was 118,000 psi. This is a significant change, especially for a material that is supposedly not time-sensitive.

Most plastics, when tested in the millisecond time scale, show tensile strengths of about double the values obtained in tests at the conventional rates.[1] Some solid propellants tested in our laboratory had a fivefold increase in tensile strength when tested at high rates.

Since many fabricated items are subjected to high-rate stresses, the need for information on high-rate tensile strength is obvious. Unfortunately, the high-rate tensile behavior of a material cannot be predicted from the conventional tension test. It can be obtained only by testing at high rates of loading.

The high-rate tension tester described in this paper employs the idea, reported by Dorsey *et al.*[2] of the rapid release of compressed gas to provide the high rate of loading on the test specimen.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] S. Strella and L. Gilman, "High Rate Tensile Properties of Thermoplastics," *Modern Plastics*, April, 1957.

[2] J. Dorsey, F. J. McGarry, and A. G. H. Dietz, "High-Speed Tension Testing Machine for Plastics," ASTM BULLETIN No. 211, p. 34 (Jan., 1956).

The Loading Mechanism

A diagram of the loading mechanism is shown in Fig. 1. A high-pressure gas tank is connected to a storage reservoir through a needle valve. The reservoir is connected to a single-stroke double-acting air cylinder through a fast-opening mechanical valve. The cylinder has a 4-in. diameter, is 12 in. long, and is fitted with a piston and connecting rod. Six slots, 4.5 in. long and $\frac{1}{8}$ in. wide were cut through the walls of the cylinder parallel with its axis. One of the specimen grips is connected to the connecting rod. The other grip is connected through a weighbar to a metal support stand.

In operation, high-pressure gas is admitted to the storage reservoir. This stored gas is then rapidly released into the air cylinder by means of the fast-opening valve. The high-pressure gas forces the piston to move extremely fast, thus loading the specimen in a matter of milliseconds. When the piston has traveled $2\frac{3}{8}$ in., the slots in the cylinder wall allow the gas to escape, thus reducing the force of the gas on the piston to

STEPHEN STRELLA has been engaged in research on the physical behavior of plastics for the past five years. He recently joined the Monsanto Chemical Co. Special Projects Dept., Everett Station, Boston, Mass. as a research physicist.

HAROLD SIGLER, formerly with the Plastics Research Section of Picatinny Arsenal as a materials engineer—plastics, is now with Fairchild Graphic Equipment Co. as a senior engineer.

MITCHELL CHMURA, (not shown) laboratory technician, has been with the Plastics and Adhesives Research Section, Picatinny Arsenal for a number of years. He is widely experienced in the testing and evaluation of plastics.

BENJAMIN HOLMAN, (not shown) laboratory aide in the mechanical testing of plastics, has been in the Plastics and Adhesives Research Section, of the Picatinny Arsenal for the past several years.

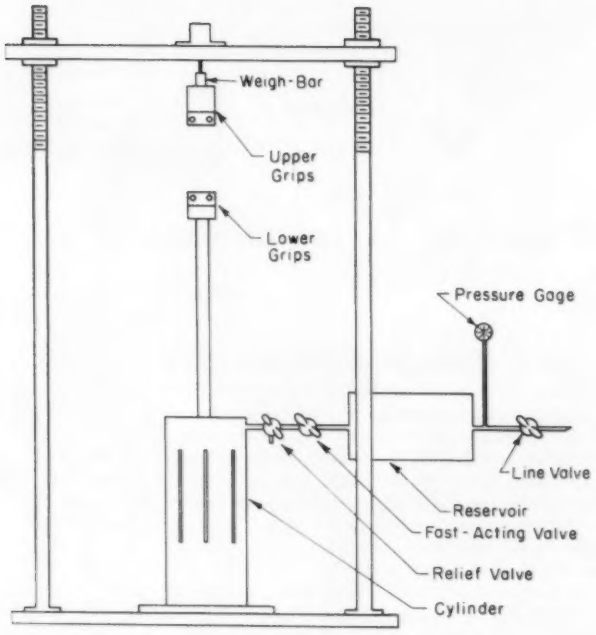


Fig. 1.—Diagram of high rate loading mechanism.

almost zero. When the piston has traveled this distance, most materials have already been fractured. For high-elongation materials such as nylon, the piston has at this point attained a velocity high enough to accomplish fracture of the specimen because, after reaching the slots, the piston continues to travel under its own momentum. When it goes beyond the slots, the piston bounces off the air cushion in the closed end, and returns to a position midway in the cylinder.

There are several advantages to this loading system. First, the specimen and grips are always exposed. This allows rapid insertion of the specimen and the use of various specimen shapes and grips. A second advantage is that a large number of specimens can be tested in less time than is required for the standard low rate tension tests.

There are also disadvantages. One is that the mechanical fast-opening valve places a limit on the loading time on the specimen. Presumably this could be improved by use of a solenoid type valve. Second, the rate of grip separation is not constant. Figure 2 shows oscilloscope traces of grip separation *versus* time, illustrating the nonlinear behavior of the grip rate of separation. However, the authors feel that to attempt to modify the above system to obtain a more constant rate of grip separation would be extremely difficult. Further, the grip separation-time function is about the same for a given gas pressure, so the difficulties involved in attempting to obtain a more constant grip-separation rate far outweigh the benefits to be gained.

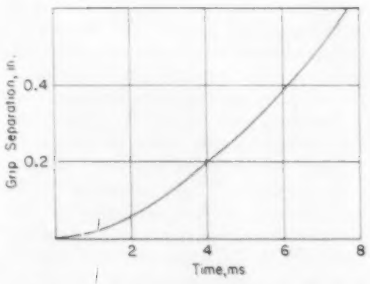


Fig. 2.—Grip separation *versus* time.

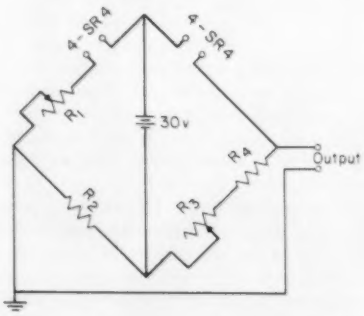


Fig. 3.—Load-measuring system diagram.

R_1 = decade, ohm steps
R_2 = 480 ohms
R_3 = 50 ohms
R_4 = 4.60 ohms

The specimen loading time of the above system is controlled by the reservoir gas pressure. Gas pressures of 1700 to 2000 psi will produce fracture in about 6 to 10 milliseconds. Gas pressures of about 150 psi will produce fractures in about 30 to 50 milliseconds. In order to obtain longer loading times to bridge the gap between milliseconds and the loading times of 30 sec or so obtainable on the static testing machines, a needle valve may be inserted between the fast-opening valve and the air cylinder to reduce the rate of flow of the gas.

The Load Measuring System

The load is measured by determining the strain on a steel weighbar. Eight type C19 SR-4 strain gages are mounted on a cylindrical weighbar, four laterally and four longitudinally. The gages are connected into a bridge circuit as shown in Fig. 3. Connection of the gages as shown provides both temperature compensation and increased sensitivity. The output of the bridge is amplified by a wide-band d-c amplifier and then fed into one d-c input channel of a dual trace oscilloscope.[3] The authors wish to emphasize that the use of widebank d-c amplification is imperative. This is apparent from the fact that a wide-band a-c amplifier that is flat down to about 5 cps and whose a-c amplification is 10 will amplify a 5 millisecond sawtooth pulse by about 9.5 times and will amplify a 40 millisecond pulse by about 5 times. Thus, if an a-c amplifier is used, on the assumption that it will amplify the load pulse by the same amount it would amplify an a-c signal, completely erroneous load information will be obtained. The whole problem is circumvented by using d-c amplification.

The calibration of the load circuit is accomplished in the following manner:

A static tension tester is utilized to provide a tensile load on the weighbar. The gain of the oscilloscope is adjusted so that throwing a 1-ohm resistance in one arm of the bridge gives a full-scale deflection. The gain of the system is increased by 10 and the weighbar loaded to give the same full-scale deflection. This is noted and the procedure is then repeated for integral resistance steps up to 10 ohm. This calibration is independent of the bridge battery voltage.

[3] Tektronix type 535 with type 53C preamplifier, Tektronix, Inc., Portland, Ore.

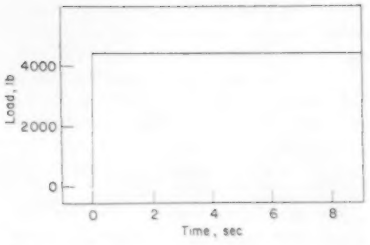


Fig. 4.—Rapidly applied constant load *versus* time.

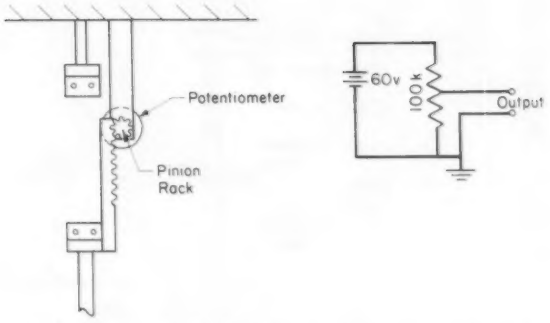


Fig. 5.—Diagram of grip-displacement measuring mechanism.

In order to insure that in using the static calibration load values proper load readings would be obtained under high-rate conditions, a simple check was performed. A steel specimen was rapidly loaded to a load below its yield and held there for several seconds. Figure 4 shows a trace of this load *versus* time. The load trace reached its maximum in several milliseconds and then remained at the same level for the several seconds it was observed. This check indicates that such effects as may be caused by mechanical resonance of the weighbar (the fundamental resonant frequency is calculated to be over 50,000 cps) or the steel's modulus being time-dependent, etc., are not sufficiently present so as to produce erroneous readings over the time scale covered by this machine.

In operation, an estimate is made of the maximum load the specimen will sustain and the oscilloscope is calibrated accordingly (one or two trial tests are usually sufficient to determine the proper load level). The oscilloscope is triggered internally by using the oscilloscope's d-c triggering mode. A Polaroid type camera is used to photograph the trace.

The Strain Measuring System

For high-modulus materials such as steel, SR-4 gages may be used to measure the strain of the specimen. The instrumentation would be a bridge circuit, a d-c amplifier, and the other channel of the oscilloscope. The strain signal would be used to drive the *X* axis of the oscilloscope, thus obtaining a load-strain trace, but the authors prefer to use a double trace having the same time base, one trace being the load and the other the strain.

For low-modulus materials such as plastics, it was found that SR-4 gages could not be used successfully on the usual ASTM type 1 tension specimen. When many types of adhesives were used to bond the gages to such materials as polystyrene and poly (methyl methacrylate), it was observed that the strain indicated by the SR-4 gage was well under the actual strain on the specimen, usually by 50 per cent. No adhesive was found that would indicate the strain to within 10 per cent. Thus the idea of using SR-4 gages on plastics was discarded.

The method used for determining the strain of plastic specimens is to calculate it from measurements of grip separation. The system is as follows:

A rack is rigidly mounted on the bottom grip as shown in Fig. 5. The teeth of the rack are meshed with those of a pinion mounted on a ten-turn potentiometer. The potentiometer is rigidly mounted to the top grip support. As the bottom grip moves, the rack turns the potentiometer, thus producing a voltage which is proportional to the grip separation. This voltage is fed to one channel of the oscilloscope; the other channel is used for the load signal. Both signals are simultaneously traced against the same time base, as shown in Fig. 6.

Values of load *versus* grip separation are then read off the photograph of the traces. Strain values are calculated from the values of grip separation by using a curve of grip separation *versus* strain obtained for each particular material by performing a low rate tension test, using the same grips and same original grip separation as in the high rate test. The load values are converted to stress in the usual manner and then plotted against the strain values.

The authors would like to point out that in this potentiometer setup all play must be reduced to a minimum since a play of several thousandths of an inch will give erroneous grip separation readings, resulting in a too high modulus value. The authors checked their modulus determinations by comparing the modulus obtained from the high-rate tester with that obtained from the vibrating reed test.[4] The values were within a few percentage points.

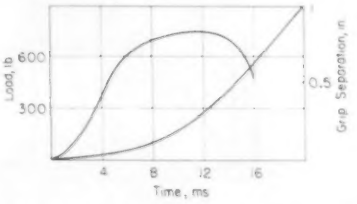


Fig. 6.—Grip-displacement and load *versus* time.

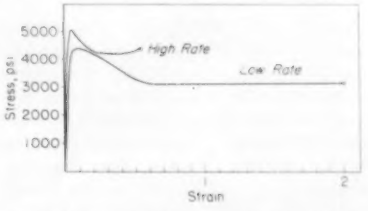


Fig. 7.—Stress-strain behavior of high density polyethylene at high and low rates of loading.

Results and Conclusions

Figure 7 shows stress-strain data obtained for a commercial high-density polyethylene at both high and low rates of tension testing. As is expected, this material exhibits higher modulus and strength values and a lower elongation when tested at a high rate of loading than it does in static testing.

Though not reported here, the high and low rate tensile properties of a number of plastic materials have already been determined as part of a project to determine these properties for a large number of commercial plastics.

The authors believe that the high-rate tension tester described above is simple, reasonably accurate, easily and rapidly operated, and moderate in cost.

[4] S. Strella, "Vibrating Reed Test for Plastics," ASTM BULLETIN No. 214, p. 47 (May, 1956).

A PROGRESS REPORT—

Measurement of Surface Moisture

By P. J. SEREDA

At its meeting in 1956 the Task Group on Measurement of Atmospheric Factors of ASTM Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys decided to study surface moisture as one of the important factors in corrosion of metals. At the meeting the author volunteered to undertake to develop instrumentation to record the time-of-wetness on exposed metal samples. This paper reports the work carried out by the Division of Building Research of the National Research Council of Canada and some of the preliminary results.

LITERATURE abounds with data on the weathering of materials exposed at certain geographic locations. Without these useful data there would be no basis for the selection of engineering materials in the construction industry. The contribution of the many ASTM technical committees to this knowledge is notable.

Wide variations in corrosion rates, attributed to local climatic conditions, have been observed and efforts have been made to measure and define the factors responsible for them. Copson (1)[1] postulated from his extensive work that the corrosion rate of steel depends upon the quality and quantity of water reaching the steel surface. Dearden (2) has attempted to correlate the corrosion of steel with the hours of rainfall registered by a recording rain gage. Ellis (3) has made an important contribution to the understanding of the effect of weather upon the initial corrosion of zinc. He determined the wetness factor by means of a device that recorded the presence of moisture on a glass plate exposed with the zinc specimens. Larrabee (4) has done much work to show the effect of rain in washing contaminants such as sulfur compounds from the skyward surface of an exposed steel specimen, and the effect of precipitation such as dew on the groundward side. Compton (5) has emphasized that conditions of exposure other than geographic location may determine the rate of corrosion.

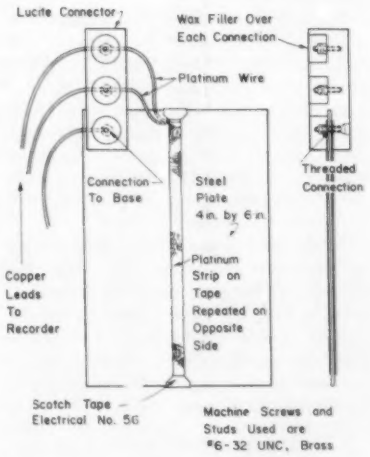

Lucite Connector
Wax Filler Over Each Connection
Platinum Wire
Connection To Base
Steel Plate 4 in. by 6 in.
Threaded Connection
Platinum Strip on Tape Repeated on Opposite Side
Copper Leads To Recorder
Scotch Tape Electrical No. 56
Machine Screws and Studs Used are #6-32 UNC, Brass

Fig. 1.—Sensing element consisting of platinum and steel.

It is an accepted fact that moisture plays an important role in all manner of deterioration and corrosion. A prime factor in the corrosion of metals is the persistence of free and even absorbed moisture, corresponding to high relative humidity, on the surface of the exposed metal specimen. Although various attempts have been made in the past to measure and record the length of time moisture persisted on the surface, the work was usually done on other than the corroding metal surface. Since the physical characteristics of the metal specimen influence the presence and persistence of moisture on its surface, it was thought that the measurement should be made on a specimen identical to the one on which corrosion is being observed. The method for measuring surface moisture presented in this report is based on a suggestion made by F. L. LaQue. It involves the measurement of the potential developed between a corroding metal specimen and an electrode of platinum placed in immediate proximity. Surface moisture serves as the electrolyte for the cell.

The Measuring Device

Since Subcommittee VII has used mild steel and zinc as calibrating materials for rating the corrosivity at the various exposure sites, these two metals were the immediate choice for the base metal in the sensing element.

The sensing element finally developed for this purpose is shown in Fig. 1. It consisted of two platinum foil electrodes 0.004 in. thick, $\frac{1}{4}$ in. wide, and $5\frac{1}{2}$ in. long, mounted on 4 by 6-in. steel or zinc panels. One electrode was mounted on each side to record the skyward as well as the groundward exposure. Scotch electrical tape No. 56 consisting of 0.002-in. film of thermosetting polyester was used to insulate the electrode from the base. This tape, $\frac{1}{4}$ in. wide, was applied on the platinum foil and similar tape, $\frac{1}{2}$ in. wide, was ap-

P. J. SEREDA, associate research officer, Division of Building Research, National Research Council, Ottawa, has been engaged since 1950 in the study of the behavior of water in porous systems including methods of detecting and measuring the presence of water on surfaces of materials.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

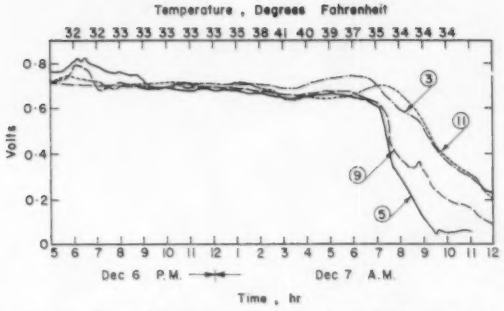


Fig. 2.—Record of potential from four platinum and steel cells during a fog at Ottawa.

5 Skyward element No. 2
9 Skyward element No. 3
3 Groundward element No. 2
11 Groundward element No. 3
Shunt Resistance 100 megohms

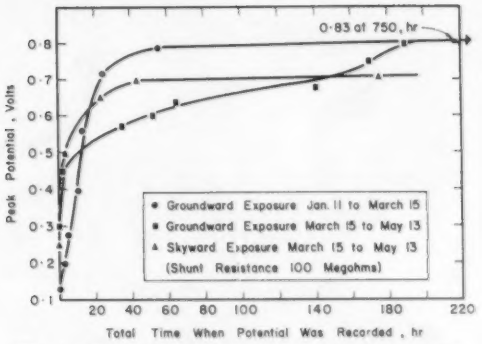


Fig. 3.—Peak potential developed by platinum and steel cell while exposed at Ottawa.

plied on the steel or zinc base. The tape on the foil was cemented to the tape on the base by means of cement E. C. 1022 (Minnesota Mining and Manufacturing Co.). Excess tape was trimmed flush with the edges of the foil with a scalpel. Connection to the platinum foil was made with 20-gage platinum wire which in turn was connected to copper leads at the special Lucite connector shown in the drawing. This connection was sealed from the weather by wax.

A Speedomax 12 point recorder, calibrated to record −0.2 to +1.8 v, registered the potential. A by-pass circuit consisting of a shunt resistance returned the recorder to zero when the element was dry. Since the value of this resistance affected the sensitivity of this device to various climatic conditions, the recorder was altered to sense the potential developed by each cell across a series of shunt resistances of 1, 5, 25, and 100 megohms. This was achieved by introducing a bank of 12 relays to work in conjunction with the 12 relays already in the recorder. The coils of the relays were coupled and were energized through the selector switch of the recorder.

Principle of Operation

The detecting element described here when covered by water, constitutes a galvanic cell. The electromotive force of such a cell can be defined in terms of the metals used for the electrodes and the type and concentration of the active ions which enter into the chemical reactions.

The electromotive force of this cell can be measured by means of a potentiometer under reversible conditions when no current is drawn from the cell. Under these conditions the electromotive force would be independent of the size of electrodes and the extent to which the electrodes were covered by the acting electrolyte. This corresponds with the maximum sensitivity for detecting moisture on the surface of this element because the cell potential is independent of the amount of moisture that is present.

Since it was desirable to measure the degree of wetness of the element, the cell was shorted externally through a shunt resistance resulting in a flow of current through this by-pass circuit. The potentiometer recorder was connected across the shunt resistance so that it measured the IR_e drop. This IR_e drop is the measured potential discussed in this paper.

In a circuit of the galvanic cell having an internal resistance, R_i, connected through an external shunt resistance R_e a current, I, will flow depending on the values of the resistances. The equation relating the electromotive force of the cell to the measured potential can be written as follows:

$$\text{Electromotive force} = IR_i + IR_e$$

The internal resistance of the cell was about 5000 megohms when dry and about 2000 ohms when completely wet. This resistance depends upon the area of the electrodes that is wetted by the electrolyte and the concentration of active ions present. For any given value of the shunt resistance the current varied as the electrodes became wetted by the electrolyte and this registered in the measured potential. As the shunt resistance was increased, the sensitivity of the element was also increased and for any given condition the measured potential was the highest when the shunt resistance was 100 megohms. When the shunt resistance was 1 megohm the sensitivity was decreased to the point that only the condition of complete wetness on the surface of the element was recorded.

When the element consisting of the cell of platinum and steel was immersed in distilled water the measured potential across the 100 megohm shunt reached a maximum of 0.6 to 0.7 v. This potential was not affected when solutions of KCL and NaCl of various concentrations were used. Addition of sulfate ion in the form of a saturated solution of sodium sulfate increased the measured potential to about 0.8 v.

Results and Discussion

Most of the work to date has been done with an element consisting of platinum and steel. Therefore, only the results obtained with this element are reported here, although the element consisting of platinum and zinc shows considerable promise. The data were obtained with the elements exposed at an angle of 30 deg to the horizontal at Ottawa, Ont., and at Halifax, N. S.

First, the reproducibility of the measured potential obtained from two separate elements was determined by observing the record during a period of fog—a very constant condition of wetness (Fig. 2). It is apparent that reproducibility was good and subsequent data have confirmed this finding without exception.

The potential measured from these cells varied from zero to a maximum of about 0.85 v under various conditions of exposure and depending on the value of the shunt resistance. It was found that a maximum potential of 0.6 to 0.7 v was recorded from the cell of platinum and steel when immersed in distilled water and connected through a 100 megohm shunt. This potential was reproduced when the cell was exposed to a heavy rainfall. After outdoor exposure for a certain time, the maximum potential increased to about 0.85 v. This rise was attributed to contaminating salts from the atmosphere. During a prolonged rainfall, this maximum decreased to a lower value on the skyward side. This decrease was attributed to leaching of the salts.

Laboratory experiments indicated

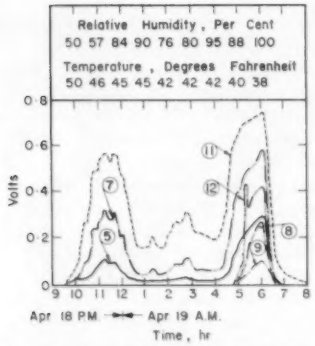

Relative Humidity, Per Cent
50 57 84 90 76 80 95 88 100
Temperature, Degrees Fahrenheit
50 46 45 45 42 42 42 40 38
Volts
Apr 18 P.M.
Apr 19 A.M.
Time, hr

Fig. 4.—Record of potential from platinum and steel cell during light dew at Ottawa.

Element No.	Shunt Resistance	Exposure
5	1 megohm	groundward
7	5 megohms	groundward
11	100 megohms	groundward
6	1 megohm	skyward
8	5 megohms	skyward
12	100 megohms	skyward

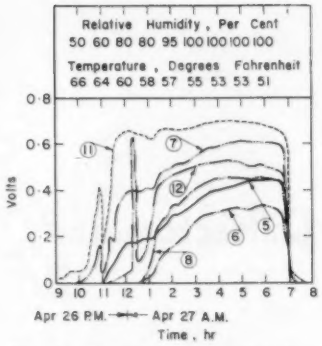

Relative Humidity, Per Cent
50 60 80 80 95 100 100 100 100
Temperature, Degrees Fahrenheit
66 64 60 58 57 55 53 53 51
Volts
Apr 26 P.M.
Apr 27 A.M.
Time, hr

Fig. 5.—Record of potential from platinum and steel cell during moderate dew at Ottawa.

Element No.	Shunt Resistance	Exposure
5	1 megohm	groundward
7	5 megohms	groundward
11	100 megohms	groundward
6	1 megohm	skyward
8	5 megohms	skyward
12	100 megohms	skyward

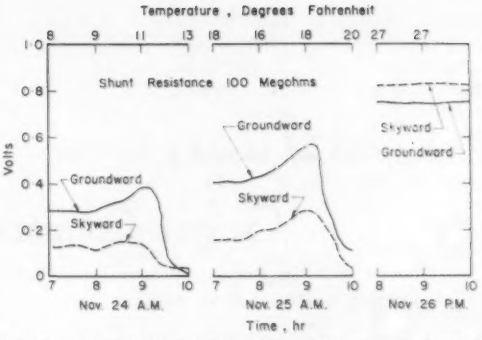


Fig. 6.—Record of potential from platinum and steel cell during snowfall at various temperatures.

that the sulfate ion caused an increase in the measured potential whereas chloride ion had no effect. Figure 3 shows that when a new element was exposed in the winter to conditions producing wetness on the surface, the measured potential increased to a higher value in a shorter total time of wetness than when the element was exposed in the spring. This finding is consistent with the fact that the SO_2 content of the air was twice as high in the month of January as in the months of March and April. The graph also shows that to record a value of 0.5 v a new element had to be exposed for only a couple of hours to conditions of wetness in the spring whereas it had to be exposed for over ten hours in the winter. This can be explained on the basis that the rate of corrosion reactions which supply the active ions for the galvanic cell, is lower when the temperature is lower. It follows, therefore, that a certain amount of corrosion products is necessary to give the cell its maximum sensitivity. On the other hand, excess scale had the opposite effect by bridging the electrodes with a low-resistance path so that loose scale, formed on the groundward side of the steel panel, had to be scraped off from the vicinity of the platinum electrode every two or three months.

In certain localities the period of wetness caused by dew represents a substantial fraction of the total period of wetness from all manner of precipitation. The records of the measured potential developed by the cells during the formation of dew were varied depending on the dew point of the air, air temperature, wind velocity, etc. A typical record is shown in Figs. 4 and 5. Light dew occurred first on the groundward side, presumably because of its proximity to the moisture coming from the ground. These records also show the effect of the shunt resistance. It is significant that the potential was recorded long before the air reached 100 per cent relative humidity. This is accounted for by the fact that the panel was cooled to a temperature below the dew point of the air by radiation loss to the sky. Laboratory experiments have shown that a potential will be recorded when the element is cooled to a temperature corresponding to the dew point of the air. This potential is very low at first because only traces of moisture are on the surface, and will reach a high value only after the element is held for over an hour at a temperature several degrees below the dew point of the air. Air currents have a considerable influence on the value of the potential measured under these conditions.

Figure 6 shows that snowfall at temperatures below and above freezing was recorded as a potential which increased with increasing temperature.

Summary and Conclusions

A method has been developed which can detect the presence of surface moisture on metal panels exposed to outdoor conditions. Sensitivity of the element can be varied so that traces of moisture on the surface as in the case of dew or snow at low temperature can be differentiated from gross moisture as during a period of rain. Finally, it is quite certain that the presence of SO_2 in the atmosphere can be detected by an increased maximum potential.

It has yet to be shown how the measured potential developed by surface moisture relates to the rate of corrosion of the metal. Work is now under way to determine whether any relationship exists between the area under the potential-*versus*-time curves and the rate of corrosion of the metal.

It is hoped that the areas under the potential-*versus*-time curves for any two periods will have the same ratio as the hours of wetness as indicated by the element having the same sensitivity. If this turns out to be the case, then an attempt will be made to develop a simple recorder to give merely the hours of wetness using these sensing elements.

The record of hours of wetness resulting from all manner of precipitation should be of great assistance not only to those studying the corrosion of metals but also in the evaluation of results of deterioration of coatings, and especially the correlation of results from accelerated aging tests with actual service performance.

Acknowledgment:

The author gratefully acknowledges the invaluable assistance of H. F. Slade and S. E. Dods in setting up the apparatus and collecting the data.

References

(1) H. R. Copson, "A Theory of the Mechanism of Rusting of Low Alloy Steel in the Atmosphere," *Proceedings*, Am. Soc. Testing Mats., Vol. 45, p. 554 (1945).

(2) J. Dearden, "Climatic Effects on the Corrosion of Steel," *Journal*, Iron and Steel Inst., Vol. 159, No. II, p. 241 (1948).

(3) O. B. Ellis, "Effect of Weather on the Initial Corrosion of Sheet Zinc," *Proceedings*, Am. Soc. Testing Mats., Vol. 49, p. 152 (1949).

(4) C. P. Larrabee, "The Effect of Specimen Position on Atmospheric Corrosion Testing of Steel," *Transactions*, Electrochemical Soc., Vol. 85, p. 297 (1944).

(5) K. G. Compton, "Outdoor Exposure Testing on Racks and Test Fences," Symposium on Conditioning and Weathering, p. 87, Am. Soc. Testing Mats. (1952). (Issued as separate publication, *ASTM STP No. 133.*)

Preparation of samples for the

Geiger Counter Diffractometer

By L. E. COPELAND and R. H. BRAGG

Reproducible relative intensity measurements are sometimes difficult to obtain in systems containing calcium hydroxide or silicate minerals. The procedure for preparing samples that is described here has given reproducible relative intensity measurements on these materials, and may be applicable to a wide variety of substances

SINCE the intensity of an X-ray reflection is proportional to the volume of crystallites oriented relative to the X-ray beam so as to satisfy the Bragg[1] relation, a sample is likely to give incorrect intensities because of (1) accidental deviations of crystallite orientations from random distribution, or (2) systematic deviations of crystallite orientations from randomness. Accidental deviations from randomness cannot be avoided; they can be reduced to any desired level by making the average crystallite size sufficiently small. Calculations show that, for silicate minerals in a modern Norelco diffractometer, a crystallite size of about 2μ is necessary to reduce the probable error in the intensity of a strong reflection to 1 per cent (1),[2] However, even if the accidental deviations from randomness are appreciable because the crystallite size of the sample is too large, the correct intensity can be obtained by averaging measurements made on a large number of samples.

The problem is different when the deviations from randomness are systematic, because in this case accuracy is not improved by repeated sampling. Samples showing systematic departures of crystallite orientations from randomness, that is, samples in which the crystallites tend to align predominantly in certain directions, are said to display preferred orientation. Preferred orientation is usually found when samples containing crystallites whose shape is acicular or tabular are *compacted* in the sample holder. Fine grinding reduces the amount of preferred orientation, but some preferred orientation is found even with powders having a maximum particle size of 2μ when the sample is *compacted* in the usual way.

Modern power supplies for Geiger counter diffractometers are so well stabilized that the errors caused by power fluctuations are trivial. However, there is an additional error contributed by the X-ray instrument which may not be trivial. This error is caused by the randomness of emission of radiation from the X-ray tube. The relative error can be made negligible by taking a sufficient number of counts in the intensity measurements.

The effects of varying fineness and the degree of compaction on the intensity of the X-ray reflections of samples containing calcium hydroxide (platy) and some silicate minerals (prismatic) have been studied. Samples sufficiently fine and free of preferred orientation can be prepared using the procedure described below.

Sample Preparation

Grinding of Samples

The necessary fineness is obtained by a method related to that described by Ballard, Oshry, and Shrenk (2). The sample is ground until further

L. E. COPELAND received his Ph.D. from the University of Chicago in 1941 and joined the staff of the Portland Cement Assn. in 1947 as senior research chemist. In 1952 Mr. Bragg and he started developing procedures for applying X-ray techniques to the analysis of the hydration products of portland cement and to the study of the physical structure of hardened neat cement pastes.

ROBERT BRAGG was with the Basic Research Section of Portland Cement Assn. for five years. With the senior author he has developed sample preparation techniques and optimum measuring procedures and contributed to the theory of quantitative X-ray diffraction analysis. He received his B.S. and M.S. degrees from the Illinois Institute of Technology where he is currently a doctoral candidate.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the authors. Address communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] W. H. Bragg, not the present author.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

grinding does not increase the precision of the integrated intensity measurements. This precision is expressed by the coefficient of variation (standard deviation divided by average) of repeated measurements, usually about ten. When obtaining integrated intensities, it is convenient to use the count register controls to accumulate counts between fixed angle limits.

The sample is first ground to pass a No. 200 sieve. A vibratory ball mill (3) is then used for the final grinding. The sample and about 1000 ¼-in. steel balls are contained in a cylindrical steel jar which is suspended by leaf springs and is swung through a circular path by a motor. This excites the balls, causing numerous collisions that grind the material in the jar. At the same time, the jar rotates slowly about its axis. In this way material does not settle to the bottom and the grinding is uniform. About 50 ml of methyl chloroform is placed in the mill to aid grinding.

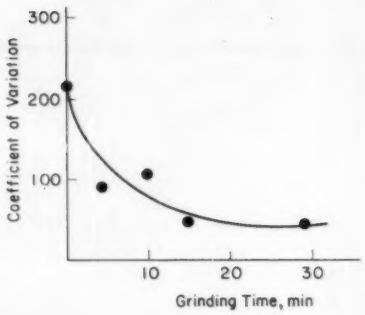
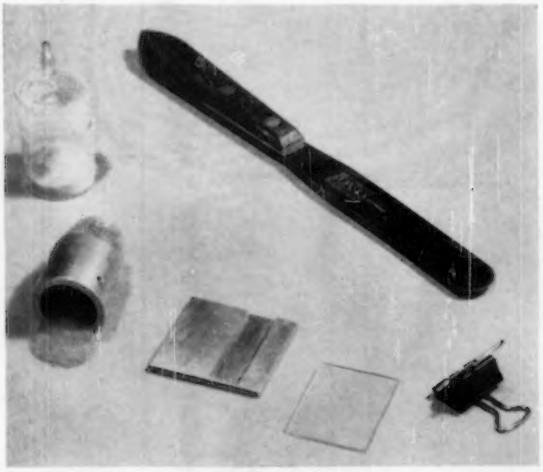


Fig. 1.—Effect of grinding on reproducibility of intensity measurements.

After grinding, the sample is a slurry coating the mill and balls. The methyl chloroform is evaporated by placing the opened jar in a vacuum oven at 50 C and maintaining reduced pressure for about 30 min. The powder is then separated from the balls by means of a No. 10 sieve. About 90 per cent of the charge is recovered; 10 per cent remains on the balls. Nearly 100 per cent recovery can be obtained by giving the balls a 2-min "flush" in the jar, using 25 ml of methyl chloroform. Contamination of the sample by iron is slight, about 0.1 per cent or less.

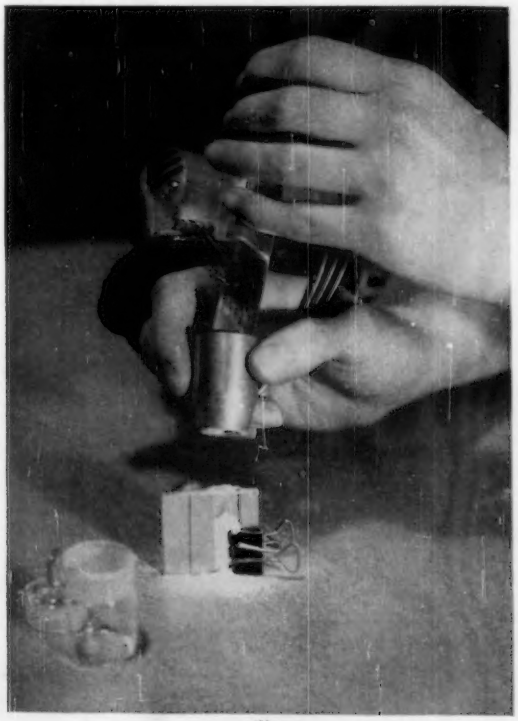
After separating the sample from the balls, it is passed through a No. 200 sieve several times to break up clumps of particles.

The time required to produce adequate fineness can be inferred from plots like Fig. 1; it is about 20 min for a 2-g sample of silicate minerals. To produce comparable results with a motor-driven mortar and pestle required about 2 hr; and with an ordinary laboratory ball mill (capacity about 500 cu cm), it required about 24 hr. Similar experiences with a motor-driven mortar and pestle and with a



(a)

(c)



(b)

Fig. 2.—*(a)* Specimen holder and accessories. (*b*) Operator in act of filling the holder. (*c*) A sample in place in the Philips diffractometer.

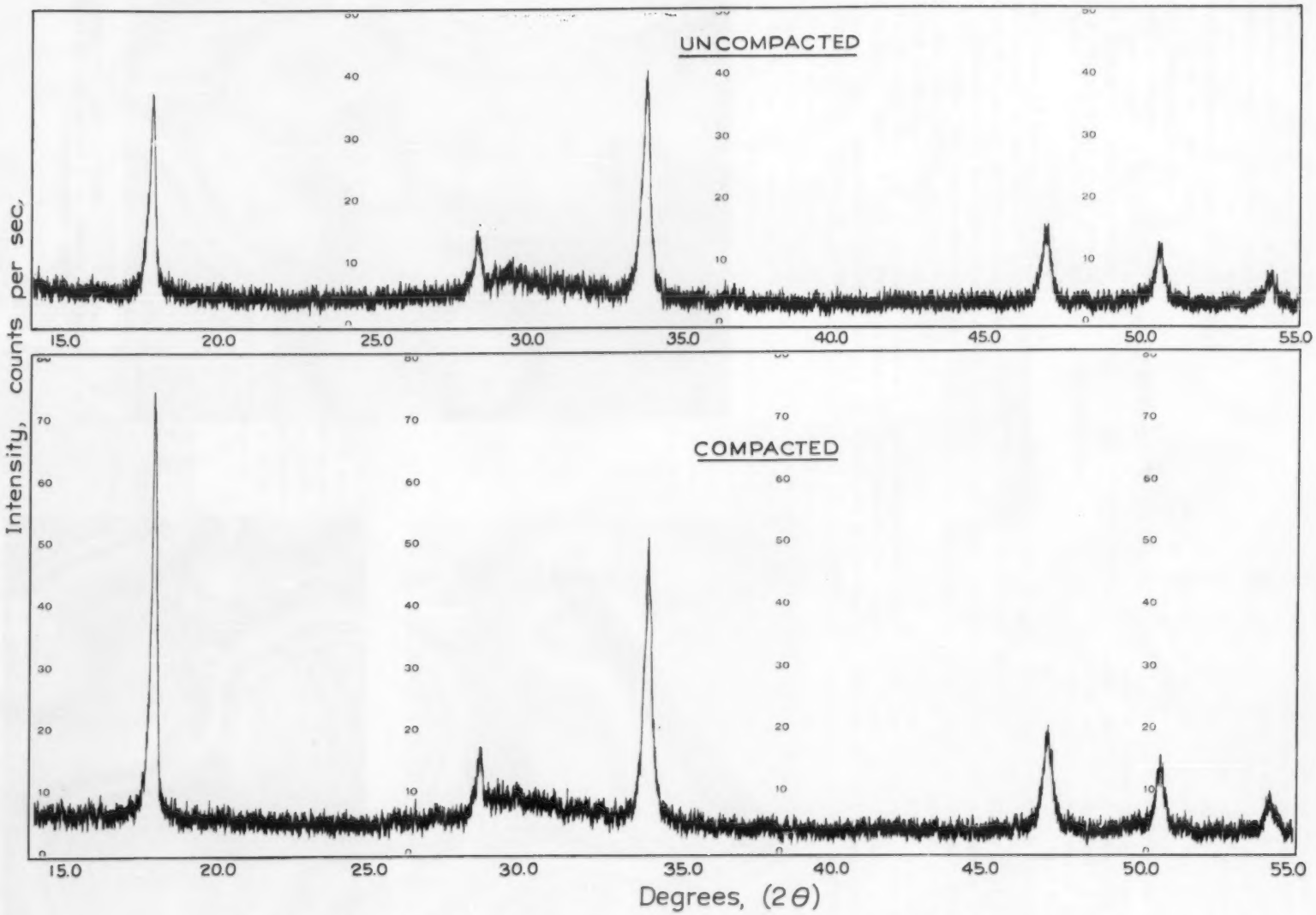


Fig. *3(a).*—Hydrated Ca_2SiO_4 containing 40 per cent $Ca(OH)_2$. The $Ca(OH)_2$ grew as large tabular crystals.

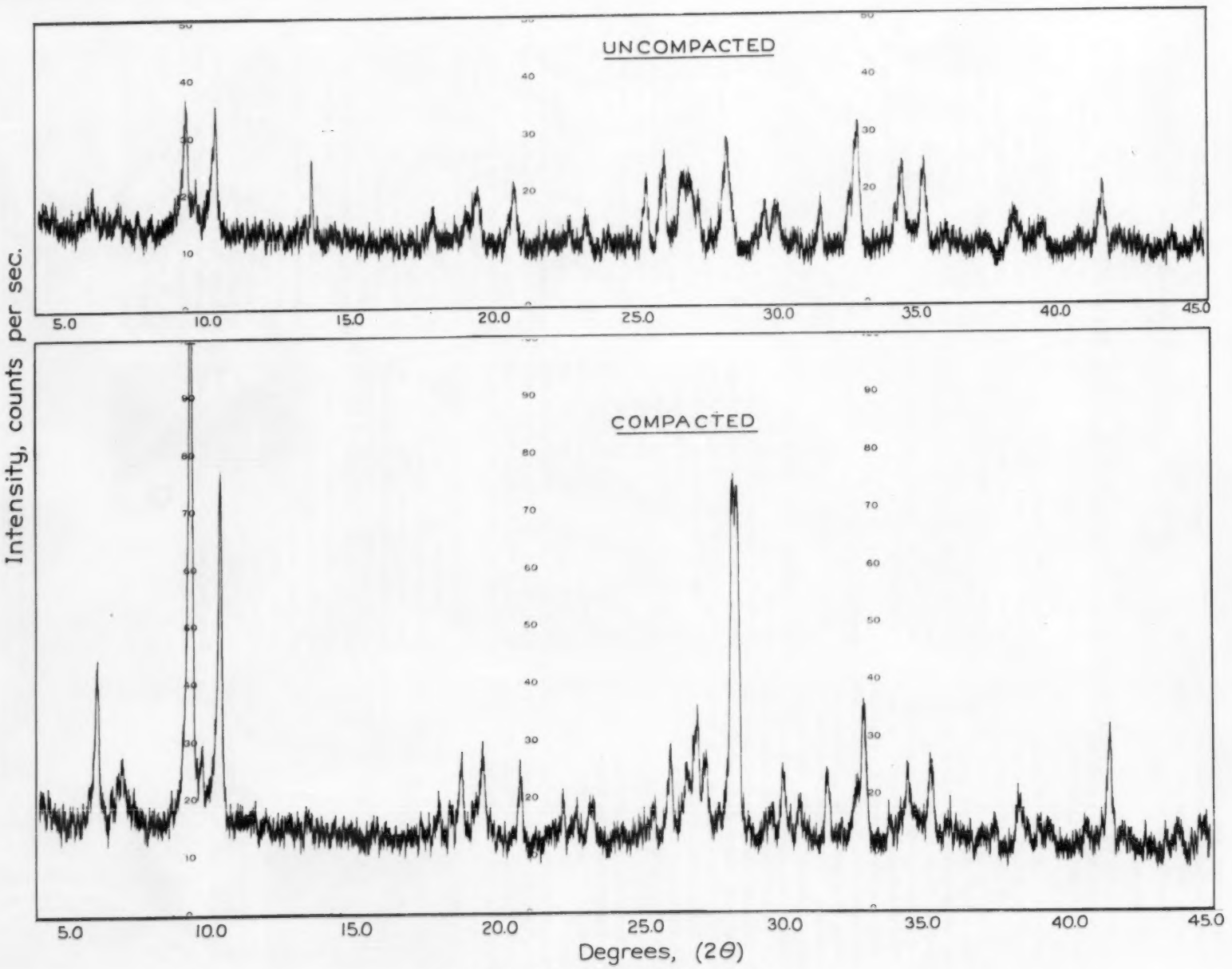


Fig. 3*(b)*.—Asbestos with vermiculite impurity.

laboratory ball mill were reported by Ballard, Oshry, and Shrenk (2). The largest particles obtained with the vibratory ball mill, as used here, were approximately 2.5μ in diameter.

Sample Mounting

Samples having random orientation are obtained by using a special holder into which the powder is allowed to fall gently without compacting it. This method is like that of Swanson and Fuyat (4) except that powder is dispensed through a small sieve. Sieving is aided by using a hand vibrator. Figure 2(*a*) shows the sample holder and accessories; Figure 2(*b*) shows an operator filling the holder; and Fig. 2(*c*) shows the sample in place in a Norelco diffractometer.

In preparing a sample, the glass slide is clamped over the open face of the holder, and powder is sifted into the open end. The glass-covered face is then turned up and the slide carefully removed without smearing the exposed face. Best results are obtained by holding one side of the slide under the thumb and lifting the other side. In this way, removing the slide is like opening a door. Finally, the surplus clinging to the end of the cell is struck off with the spatula.

The sample should not be jarred, for any quick movement may compact it. Experiments with tabular calcium hydroxide crystals showed that compaction increased the intensity of most reflections by 20 per cent, but the intensity of the basal reflection can be increased by about 200 per cent. Figure 3(*a*) and 3(*b*) shows typical charts obtained with compacted and uncompacted samples.

TABLE I.—(101) REFLECTION OF CALCIUM HYDROXIDE.

Run	Integrated Intensity per 256 counts
No. 1.....	107.2
No. 2.....	106.9
No. 3.....	106.9
No. 4.....	106.1
No. 5.....	104.3
No. 6.....	106.0
No. 7.....	106.4
No. 8.....	104.3
No. 9.....	104.8
No. 10.....	105.8
Average....	105.6 ± 1.1

TABLE II.—INTENSITY RATIO, $I(001)/I(101)$ IN CALCIUM HYDROXIDE.

Crystallite Size	Habit	Ratio	Remarks
∞	...	0.63 ± 0.05	Calculated from the crystal structure
500 Å	Equant	0.648 ± 0.019	Measurements on $Ca(OH)_2$ obtained by vapor phase hydration of CaO
2.5μ	Tabular	0.632 ± 0.024	Measurements on $Ca(OH)_2$ obtained by hydrating a hardened paste of Ca_3SiO_5
2500 Å	Tabular	0.658 ± 0.022	Measurements on $Ca(OH)_2$ prepared by hydration of CaO in boiling water

The porosity of uncompacted samples is about 90 per cent and usually the surface of the sample appears pitted. However, although porosity has been shown to affect the accuracy of absolute intensity measurements and the positions and shapes of the X-ray reflections (5,6) the relative intensities are not affected.

Results

Samples prepared as described above give highly reproducible total intensities. Table I shows typical data obtained in repeated measurements of the (101) reflection of calcium hydroxide. Nickel filtered radiation from a copper target tube operated at 40 kv and 20 ma was used. In each run, counts were totalled as the goniometer scanned the angular region 36 to 32 deg (2θ) at 1 deg per min. The maximum of the (101) reflection occurs very near 34.1 deg (2θ). Since the average value of the integrated intensity was $N = 105.6 \times 256$ counts, the instrumental error was $\sqrt{N}$ or 0.64×256 counts compared to the observed 1.1×256. Consequently, the part of the total error that can be attributed to sample preparation is small.

Table II lists values of the ratio of the intensities of the (001) to (101) reflections of calcium hydroxide derived from several sources. The data for line 3 were obtained from the same sample as in Fig. 3. Line 1 gives the result of a direct calculation from the crystal structure of calcium hydroxide. The estimated range of the calculated ratio takes account of small uncertainties in a structural parameter and in the temperature factor.

The data in Table II show that the method of sample preparation described above produces a high degree of randomness in samples containing tabular calcium hydroxide. The ratios obtained from measurements on tabular crystallites, agree within the experimental error with that obtained on equant crystallites, and all the experimental values agree with the calculated value. Agreement was also obtained between relative intensities measured on equant and prismatic crystallites of afwillite (7).

References

(1) L. Alexander, H. P. Klug, and E. Kummer, "Statistical Factors Affecting the Intensity of X-rays Diffracted by Crystalline Powders," *Journal Applied Physics*, Vol. 19, Aug. 1948, p. 742.

(2) J. W. Ballard, H. I. Oshry, and H. H. Shrenk, "Sampling, Mixing and Grinding Techniques in the Preparation of Samples for Quantitative Analysis by X-ray Diffraction and Spectrographic Methods," *Journal*, Optical Soc. Am., Vol. 33, Dec. 1943, p. 667.

(3) F. H. Forziatti, W. K. Stone, J. W. Rowen, and W. D. Appel, "Cotton Powder for Infrared Transmission Measurements," *Journal of Research*, Nat. Bureau Standards, Vol. 45, Aug. 1950, p. 109. (*RP*2116).

(4) H. E. Swanson and Ruth K. Fuyat, "Standard X-ray Diffraction Powder Patterns," *Circular 539*, Nat. Bureau Standards, Vol. II, June 1953.

(5) Z. W. Wilchinsky, "Effect of Crystal, Grain and Particle Size on X-ray Power Diffracted from Powders," *Acta Crystallographica*, Vol. 4, Jan. 1951, p. 1.

(6) D. T. Keating and B. E. Warren, "The Effect of Low Adsorption Coefficient on X-ray Spectrometer Measurements," *Review Science Instruments*, Vol. 23, Oct. 1952, p. 519.

(7) S. Brunauer, L. E. Copeland, and H. Bragg, "The Stoichiometry of the Hydration of Tricalcium Silicate at Room Temperature I. Hydration in a Ball-Mill," *Journal of Physical Chemistry*, Vol. 60, Jan. 1956, p. 112.

Application of ion-exchange chromatography to the

Analysis of Commercial Triphosphate

By W. G. SPANGLER, D. E. HOWES, Jr., and J. A. KISH

COMMERCIAL sodium triphosphate is a complex mixture of ortho-, pyro-, and triphosphate together with small quantities of metaphosphate and higher phosphates, usually designated as glassy phosphates.

Simple mixtures of orthophosphate and pyrophosphate can be quantitatively analyzed by methods of acceptable accuracy and precision. The presence of triphosphate complicates the analysis.

Some of the recent methods of analysis that have been proposed for analyzing mixtures of ortho-, pyro-, and triphosphate, are:

Ion exchange chromatography (**1, 2, 3, 12**)[1]
Paper chromatography (**4**)
Bell procedure (gravimetric) (**5, 6**)
X-Ray diffraction (**7**)
Cobalt reagent procedure (**8**)
Alkaline hydrolysis procedure (**9**)
Isotope dilution method (**10**)

Several of these methods are empirical while others lead to analytical difficulties. We have found the chromatographic methods to be the best. Based on extensive work in our laboratory, we have concluded that the ion exchange method is the most practical procedure of analysis considered from the viewpoint of simplicity, accuracy, precision, and the analytical ability required to perform it successfully. So highly confident are we of its suitability, we are taking preliminary steps to employ it in our domestic and foreign control laboratories.

Principle of the Ion Exchange Method

Rieman (**1, 2**) at Rutgers University found that ion exchange chromatography provides a reliable analysis for mixtures of ortho-, pyro-, and triphosphate. The method is based first on the exchange of all negative ions in the solution phase with the negative ions in the resin phase. This exchange is brought about with the help of an anion exchange resin. Figure 1 illustrates how the negatively charged phosphate ions exchange with the anionic resin.

$$2R\text{-Cl} + \underset{\text{Ortho-phosphate}}{HPO_4^{=}} \rightleftarrows R_2\text{-}HPO_4 + 2Cl^-$$

$$2R\text{-Cl} + \underset{\text{Pyro-phosphate}}{H_2P_2O_7^{=}} \rightleftarrows R_2\text{-}H_2P_2O_7 + 2Cl^-$$

$$2R\text{-Cl} + \underset{\text{Tri-phosphate}}{H_3P_3O_{10}^{=}} \rightleftarrows R_2\text{-}H_3P_3O_{10} + 2Cl^-$$

(Anion resin)

Fig. 1.—Phosphate resin ion exchange.

R represents the nonexchangeable insoluble polymeric portion of the resin.

Second, the method is based on the internal separation of the ortho-, pyro-, and triphosphate ions with respect to their differences in affinity for the resin. When an electrolyte is passed through a column of phosphate-containing resin, orthophosphate, having the lowest affinity for the resin, will separate first, then pyrophosphate, and lastly, triphosphate.

Scope

The following methods are applicable to triphosphate raw material analysis. Method 1 is a relatively rapid control method whereby only the orthophosphate and pyrophosphate are determined by elution. The triphosphate along with a small percentage of higher phosphates is calculated by difference. Method 2 is a referee method in which all three, ortho-, pyro-, and triphosphate, are determined directly by elution. If there is doubt as to the validity of the triphosphate result obtained by method 1, the sample can be checked by method 2 and the triphosphate determined directly.

Methods of Analysis in Brief

Method 1

The sample is dissolved in water and an aliquot of the solution is placed on the anion exchange column. The column is then eluted with 0.25 *M* potassium chloride at a rate of flow of 25 ml of eluant per 10 ± 1 min. The eluant is collected in sixteen 25-ml

W. GILBERT SPANGLER, group leader in research chemistry, Colgate-Palmolive Co., Jersey City, N. J., is engaged in developing methods of analysis for detergents and builders.

DOUGLAS E. HOWES, JR., is in the methods group of the Research and Development Department at Colgate-Palmolive Co. where he has investigated numerous methods for analyzing company products and raw materials.

JOHN A. KISH, at present with the Stauffer Chemical Co. previously worked in the organic identification and methods groups of the Research and Development Department of Colgate-Palmolive Co.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

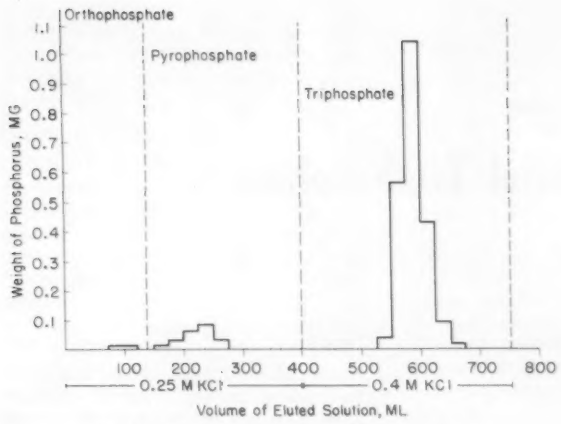


Fig. 2.—Elution curve through triphosphate.

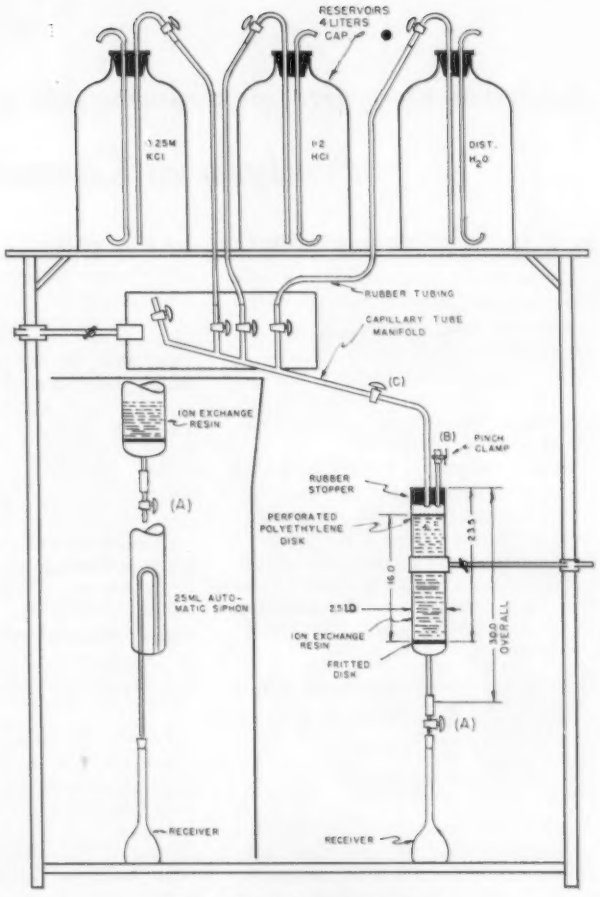


Fig. 3.—Ion exchange apparatus.
Dimensions in centimeters.

fractions and the phosphorus content in each fraction is determined colorimetrically. Ortho and pyrophosphate are determined directly and the percentage of triphosphate, along with the included higher phosphates, is calculated by difference from the total phosphate content of the sample.

Method 2

The same procedure employed in method 1 to elute the ortho and pyrophosphate is also used in method 2 to elute these two species. After pyrophosphate has been completely eluted, the eluant is changed to 0.4 *M* potassium chloride and approximately 350 ml of this eluant are collected. This volume will contain all of the triphosphate which may then be calculated from the phosphorus content of these fractions. Figure 2 shows a typical elution curve obtained by analyzing a commercial triphosphate sample according to method 2.

The operation of collecting fractions requires about 2½ hr for method 1 and 5 hr for method 2. The work involved can be rendered less tedious by utilization of mechanical means of separating the fractions.

Apparatus

A complete diagram of the assembled apparatus is shown in Fig. 3.

Reservoir Bottles—Three each as follows: capacity—4 liter; narrow mouth; equipped with a tight fitting rubber stopper through which passes a glass tube vent for pressure regulation and a glass siphon tube with stopcock—both tubes should extend to the bottom of the reservoir.

Capillary Manifold—A thick-wall glass capillary tubing, equipped with four stopcocks, securely mounted on a stationary board under the reservoir platform.

Chromatographic Glass Tube—Fitted with a fritted glass disk of coarse porosity, over-all length, 30 cm; tube length above the fritted disk, 23.5 cm inside diameter, 2.5 cm. Attach a glass stopcock with buret tip by means of a short piece of rubber tubing to the lower outlet end of the tube. Provide the tube with a tight-fitting rubber stopper through which passes a glass tube vent assembly and an inlet delivery tube with a stopcock—both tubes should extend about 1 cm below the rubber stopper.[2]

Perforated Polyethylene Disk—Diameter, 2 cm; thickness, 1 mm; having three holes about 6 mm in diameter. The disk is placed on the surface of the resin bed in the column.

Platform—Sturdy construction, erected 4 ft above the laboratory bench top.

Klett-Summerson Photoelectric Colorimeter.—Industrial Model 900-3 with No. 42 filter using 10 mm, 20 mm and 40 mm solution cells.

Semimicro Buret—Calibrated, capacity, 10 ml, graduated in 0.05 ml subdivisions.

Volumetric Flasks, 25 ml and 100 ml.

Automatic Siphon—25 ml delivery; obtainable from the Eastern Glass Apparatus Co., 51 Morris Avenue, Newark, N. J.

Automatic Dispensing Pipets—3, pipet capacity, 10 ml; obtainable from the Scientific Glass Apparatus Co., Bloomfield, N. J., Cat. No. J-2133.

Washers—25, stainless steel, inside diameter, 1 in.; outside diameter, 2¼ in.; thickness, ⅛ in.; obtainable from any reliable hardware supply house.

[2] The chromatographic glass tube described here may be obtained from Eastern Glass Apparatus, 51 Morris Ave., Newark, N. J.

METHOD 1—CONTROL METHOD TRIPHOSPHATE BY DIFFERENCE

Reagents

0.1 M Acetate Buffer Solution (CH_3COOK).—Weigh 6.92 g of cp potassium acetate and transfer to a 1 liter volumetric flask. Add 1.8 g of glacial acetic acid and dilute to volume with water at room temperature. Mix well. Transfer the prepared solution to a large beaker and adjust the pH to 5.0 with dilute potassium hydroxide or dilute acetic acid using a pH meter. Add a small amount of phenyl mercuric chloride (nitrate or acetate) to inhibit mold growth and mix well.

0.25 M Potassium Chloride (KCl), Adjusted to a pH of 5.0.—Weigh 37.28 g of cp potassium chloride and transfer to a 2 liter volumetric flask. Add 100 ml of 0.1 *M* acetate buffer solution, swirl to dissolve, and dilute to volume with water at room temperature. Mix well. Transfer the prepared solution to a large beaker and adjust the pH to 5.0 with dilute potassium hydroxide or dilute acetic acid using a pH meter. Add a small amount of phenyl mercuric chloride (nitrate or acetate) to inhibit mold growth and mix well.

Ammonium Molybdate Solution ($(NH_4)_6Mo_7O_{24}\cdot 4H_2O$, 5 per cent.

Ammonium Vanadate Solution (NH_4VO_3), 0.25 per cent.

Nitric Acid (HNO_3), 1:2.

Hydrochloric Acid (HCl), 1:2.

Potassium Phosphate, Monobasic (KH_2PO_4) cp (dried at 105 C for 1 to 2 hr).

Anion Exchange Resin, Analytical Grade AG. 1-X8, 100–200 mesh, chloride form; obtainable from Bio-Rad Laboratories, 800 Delaware St., Berkeley, Calif.

Procedure

Part I. Preparation and Reconditioning of Ion Exchange Column

Preparation of Ion Exchange Column

(1) Clean the chromatographic tube with dichromate cleaning solution and rinse well with water.

(2) Invert the chromatographic tube and place the lower end in a beaker of water. Applying gentle suction to the tapered upper end, draw the water all the way up to this tip. Close stopcock at tapered end and turn column back to upright position. This technique is used to eliminate air bubbles below and above the fritted disk.

(3) Securely fasten the tube in a vertical position to a sturdy laboratory bench stand.

(4) Wash approximately 100 g of ion exchange resin by mixing with 300 ml of water in an 800-ml beaker. Allow to settle for a few minutes and then decant and discard the supernatant water layer. Repeat several times until no more fine suspended matter appears on the surface of the water.

(5) Prepare a 1:1 slurry of washed resin and water. With the stopcock of the tube adjusted to permit slow drainage, carefully pour a portion of the resin slurry into the tube. Allow to settle but do not permit the water level to fall below the level of the resin bed. Avoid formation of any trapped air pockets.

(6) Repeat the addition of the resin slurry as in step (5) until the height of the resin bed is 15 to 17 cm. Permit elution of the water until its level is 1 to 1.5 cm above the level of the resin bed. Close the stopcock.

NOTE.—At no time during the procedure should the level of the liquid above the resin bed be permitted to run below the top surface of the resin column. If during any part of the procedure the column runs dry, the resin should be removed, slurried again with water and the determination repeated from step 4. This is very important since any air pockets in the resin bed will cause channeling and erroneous results.

(7) Place a perforated polyethylene disk on the resin surface and complete the assembly of the apparatus as shown in Fig. 3.

(8) Close vent *B;* open the appropriate stopcocks *A* and *C*, and pass 500 ml of 0.25 *M* potassium chloride solution through the column at full elution rate. Stop the flow of electrolyte from the column and the source. The apparatus is now conditioned.

Reconditioning Ion Exchange Column

After a sample determination, the ion exchange column is reconditioned in preparation for a future determination as follows:

(1) Close vent *B;* adjust the appropriate stopcocks and pass approximately 100 ml of 1:2 hydrochloric acid from the reservoir through the column. Stop the flow of dilute acid so that the resin bed is completely covered with solution. Let stand overnight.

(2) Open vent *B;* lower the liquid level to the top of the resin bed and wash the internal walls of the column (above the resin bed) with water. This is accomplished by filling the column with water from the reservoir and then permitting the water to pass through the column until the liquid level coincides with the top surface of the resin bed.

(3) Pass 100 to 150 ml of water through the column followed by 100 to 200 ml (approximately ½-hr elution) of 0.25 *M* potassium chloride solution. Maintain a liquid level of approximately 1 cm above the level of the resin bed.

(4) The ion exchange column is now ready for sample analysis (Part II).

Part II. Sample Analysis

NOTE.—The elution of the sample should be started and completed on the same day and sample solutions should not be kept for periods longer than 1 day.

(1) Before beginning the sample analysis, the prepared ion exchange system must be reconditioned as described in Part I. If the system, after reconditioning, has not been used for several days, pass approximately 50 ml of 0.25 *M* potassium chloride electrolyte through the column and discard the eluted solution.

(2) Weigh a sample containing 60 to 65 mg of phosphorus and transfer to a 250 ml volumetric flask. Add 100 ml of water, swirl to dissolve the sample completely and dilute to volume with water at room temperature.

NOTE.—For samples of $Na_5P_3O_{10}\cdot 6H_2O$, the usual sample weight would be 0.31 to 0.34 g (to the nearest mg) based on an average P_2O_5 content of 44 per cent. For samples of $Na_5P_3O_{10}$ anhydrous, the sample weight would be 0.24 to 0.26 g (to the nearest mg) based on an average P_2O_5 content of 57 per cent.

(3) Drain the column so that the liquid level above the column is brought almost to the top level of the resin bed. This is accomplished by opening the vent, *B*, and the lower stopcock, *A*, of the column. When the liquid level is even with the top of the resin bed, close stopcock thus holding the liquid level at this point. *This is the starting point for all determinations.*

(4) Place a dry 25 ml volumetric flask in position under the column and remove the rubber stopper assembly from the column.

NOTE.—The use of a 25-ml automatic syphon will facilitate the subsequent collection and color development of the eluted fractions. If an automatic siphon (Fig. 3) is used, substitute 100 ml volumetric flasks for the 25 ml volumetric flasks specified in steps (4) and (8). Also, in this case, omit step (9) which becomes unnecessary.

Carefully pipet a 10 ml aliquot of the sample solution from step (2) into the column. Lower the liquid slowly into the column until the level almost coincides with the top of the resin bed, collecting the eluted solution in the volumetric flask. Replace the rubber stopper assembly.

(5) With vent *B* open and the lower stopcock, *A*, closed, add 10 to 15 ml of 0.25 *M* potassium chloride solution. Wash the internal walls of the column above the resin bed by slowly lowering the electrolyte level to coincide with the top of the resin bed.

(6) Add enough 0.25 *M* KCl to give a liquid level above the resin bed of approximately ½ cm. Close the vent *B*.

(7) Adjust the stopcocks *A* and *C* so that the 0.25 *M* KCl solution flows dropwise into the column and an elution rate of 25 ml per 10 ± 1 min is attained. It is very important to maintain this flow rate during the subsequent elutions.

(8) Continue the elution, collecting the eluted fractions in successive, dry 25 ml volumetric flasks until all of the ortho-and pyrophosphates have been eluted from the column. This elution usually requires no more than 16 flasks or a total of 400 ml of effluent.

(9) Quantitatively transfer each eluted portion to a corresponding 100 ml volumetric flask with the aid of 10 to 20 ml of water. See Note above.

(10) Add 10 ml of 1:2 nitric acid to each flask and dilute to a volume of 60 to 70 ml. Place the flask in a boiling water bath for 35 min. (Place a metal washer around the neck of each flask to stabilize the flask in the water bath.) Cool to room temperature.

NOTE.—It is expedient to pipet the color developing solutions using an automatic 10-ml dispensing pipet.

(11) Pipet 10 ml of ammonium vanadate solution into each flask and swirl to mix. See Note above.

(12) Pipet 10 ml of ammonium molyb-

date solution into each flask and swirl to mix. See Note above.

(13) Dilute the contents of each flask to the mark with water at room temperature. Stopper, mix well, and let stand for 30 min.

(14) Transfer a portion of each solution in turn from step (13) to a 40-mm Klett cell. Using the first or second fraction (the one of lowest color development) as a blank and a No. 42 blue filter, record the Klett number directly from the Klett colorimeter. Use the same cell for the blank and subsequent solutions throughout the Klett determinations, rinsing the cell with a portion of the solution to be read before each determination.

NOTE.—Check the Klett colorimeter with the blank solution after every four or five determinations.

(15) Determine and record the milligrams of phosphorus for each solution in turn (fraction 1 to 16) by reference to the standard curve, Part III.

Typical Interpretation

NOTE.—This interpretation is intended to serve as a guide and should not be regarded as a strict interpretation for all analyses of triphosphate raw material as minor variations in fractions members may occur. For instance, it is quite possible that the separation of ortho- and pyrophosphate may occur with fraction No. 5 and/or, occasionally the break between the ortho-and pyrophosphate may appear as a minimum rather than a zero phosphate content. In the latter case, the minimum phosphorus content is divided equally between the two forms.

Fraction No.	Interpretation
1 or 2 (50 ml)	Absence of phosphorus shows complete conditioning of ion exchange columns.
3, 4, and 5 (75 ml)	Phosphorus due to orthophosphate.
6 and 7 (50 ml)	Absence of phosphorus in either one shows complete separation of ortho-and pyrophosphates. There should be at least one fraction containing no apparent phosphorus.
8 through 13 or 15 (150 to 200 ml)	Phosphorus due to pyrophosphate.
16 (25 ml)	Absence of phosphorus shows complete elution of pyrophosphate.

(16) Total separately the milligrams of phosphorus corresponding to ortho-and pyrophosphate.

Part III. Preparation of Standard Curve

(17) Accurately weigh 0.4393 g of dried cp KH_2PO_4 and transfer to a 1 liter volumetric flask.

(18) Add 600 to 700 ml of water, swirl to dissolve the salt and dilute to the mark with water at room temperature. Mix well. One (1) ml of this solution is equivalent to 0.1 mg of phosphorus.

(19) Accurately measure from a semimicro buret 0.5, 1.0, 1.5, 2.0, and 3.0 ml of KH_2PO_4 solution into separate 100 ml volumetric flasks.

(20) Dilute to approximately 50 to 60 ml with water and add 10 ml of 1:2 nitric acid. Prepare a blank by adding 10 ml of 1:2 nitric acid to 60 ml of water in a 100 ml volumetric flask.

(21) Follow steps (11) through (14) of the sample analysis procedure using the blank prepared in the preceding step. Record the Klett numbers directly from the instrument.

(22) Using rectangular graph paper plot the Klett number *versus* concentration of phosphorus. For total phosphorus and method 2, similar curves should be constructed using 20 mm and 10 mm cells.

Part IV. Determination of Total P_2O_5

For the determination of total P_2O_5 employ any standard procedure.

Calculations

1. Total milligrams P for orthophosphate × 0.2291/Weight of sample in aliquot = per cent P_2O_5 due to orthophosphate
   Per cent P_2O_5 due to orthophosphate × 2.310 = per cent Na_3PO_4
2. Total milligrams P for pyrophosphate × 0.2291/Weight of sample in aliquot = per cent P_2O_5 due to pyrophosphate
   Per cent P_2O_5 due to pyrophosphate × 1.873 = per cent $Na_4P_2O_7$
3. Per cent total P_2O_5 − (Per cent P_2O_5 from orthophosphate + per cent P_2O_5 from pyrophosphate) = per cent P_2O_5 due to triphosphate and other higher phosphates.
   Per cent P_2O_5 due to triphosphate × 1.728 = per cent $Na_5P_3O_{10}$ (plus higher phosphates)

METHOD 2—ALTERNATE METHOD TRIPHOSPHATE BY DIRECT ELUTION

Reagents

Reagents specified under method 1 plus the following:

0.40 M Potassium Chloride Solution (KCl)—Prepare in the same manner as the 0.25 *M* KCl but use 59.6 g of cp potassium chloride per 2 liters of solution. Adjust to pH of 5.0 with the acetate buffer solution.

Procedure

Sample Analysis

(1) Follow method 1, Parts I and II through step (8).

(2) Close stopcocks *A* and *C* and open vent *B*. Place the next clean, dry 25 ml volumetric flask in position under the column. Lower the electrolyte level in the column until the level almost coincides with the top of the resin bed. Close stopcock *A*.

(3) Remove the rubber stopper assembly from the column. Replace the 0.25 *M* potassium chloride reservoir with 0.40 *M* potassium chloride solution reservoir. Open stopcock *C* and rinse the tubing system with the new eluant, collecting 25 to 30 ml in a beaker and discarding. Close stopcock *C*.

(4) Replace the rubber stopper assembly on the column. With vent *B* open and the lower stopcock *A* closed, add enough 0.40 *M* potassium chloride to give a liquid level of approximately ½ cm above the resin bed. Close the vent *B*.

(5) Adjust the stopcocks *A* and *C* so that the 0.40 *M* potassium chloride solution flows dropwise into the column and an elution rate of 25 ml per 10 ± 1 min is attained.

(6) Continue the elution, collecting the eluted fractions in successive, dry 25 ml volumetric flasks until all the triphosphate has been eluted from the column. This elution usually requires no more than an additional 14 flasks or a total of 350 ml of effluent.

(7) Prepare fractions 1 through 30 for color development and Klett reading as described in method 1—Part II.

(8) Total separately the milligrams of phosphorus corresponding to ortho-, pyro-, and triphosphate.

Calculations

1. Orthophosphate as per cent Na_3PO_4 See calculations under Method 1.
2. Pyrophosphate as per cent $Na_4P_2O_7$
3. Total milligrams P for triphosphate × 0.2291/Weight of sample in aliquot = per cent P_2O_5 due to triphosphate
   Per cent P_2O_5 due to triphosphate × 1.728 = per cent $Na_5P_3O_{10}$

Accuracy and Precision

The accuracy of the ion-exchange method was established by analyzing specially purified triphosphate of known purity (**5**). The accuracy was found acceptable.

The interlaboratory precision of the method was determined by having several analysts determine the triphosphate content of a sample of known purity in duplicate at intervals of several days. All results were found significant. The interlaboratory precision was statistically estimated (95 per cent limits) to be as follows:

	Simultaneous Duplicates	Over-all
TSPP	±0.66	±1.04
TPP	±0.98	±1.22

Results

A number of samples of commercial triphosphate were analyzed by method 1. Table I lists the results. Since the ortho and pyrophosphates present in commercial material may exist in several forms and not simply as Na_3PO_4 and $Na_4P_2O_7$, the results may also be reported on a P_2O_5 basis which simply gives the percentage of total P_2O_5 present in each form regardless of type. This is probably a more realistic method of reporting. Calculation of results in Table I on this basis gives data shown in Table II.

Discussion

The two methods of analysis are open to a number of improvements which

would result in simplification of procedure with consequent reduction in time required for analysis and reduction in tedium for the analyst.

1. An automatic fraction collector could be incorporated into the system. There are a number of collectors, operating on a weight, volume, or electronic principle, available commercially.

2. Work done by Beukenkamp, *et al* (1) showed the optimum elution rate to be about 10 to 20 min per 25 ml fraction on columns 2.5 cm in diameter. They also concluded that a rate of 7 min per 25 ml fraction gave too much overlapping and tailing.

A sample of commercial triphosphate was run at three different elution rates and comparable results obtained. Table III shows these results. There is, therefore, a good possibility of reducing elution time, provided adequate separation of ortho- and pyrophosphates is obtained.

3. The two methods at present call for regeneration of the resins by passing 1:2 HCl through them at the end of a determination and letting them stand overnight in the presence of the acid. Experimental data have shown the feasibility of running more than one sample through a column in the course of one day. Table IV shows results obtained on a commercial triphosphate sample which was analyzed twice on the same day in the same column. Between determinations, the column was regenerated simply by passing the acid through the resin and then preparing the column in the usual manner for reception of the second sample.

4. If it is desired to determine the amounts of higher phosphates which may be found in a triphosphate sample, the method of Rieman *et al* (11) can be used. After the elution of the triphosphate, 0.5 *M* potassium chloride buffered at pH of 5.00 and 1:2 HCl are used as eluants. The 0.5 *M* potassium chloride will separate (*a*) a mixture of tetrametaphosphate and tetraphosphate and (*b*) trimetaphosphate. The acid will separate Graham's salt ($(NaPO_3)_x$ where x is some value above 100). This method also provides for the separation of tetrametaphosphate and tetraphosphate by running a separate determination using eluants buffered at pH of 9.00.

5. Methods 1 and 2 have proved very useful in the analysis of finished products. Originally a slightly different assembly was used to overcome any interference from silicates present in the finished products. An auxiliary column 10 cm in length, equipped with a coarse porosity fritted glass disk, and fitted with a tapered drip tube was placed on top of the main column, the two being held together by a ground glass joint.

TABLE I.—SAMPLES OF COMMERCIAL TRIPHOSPHATE AS ANALYZED BY METHOD 1 REPORTED ON "AS-RECEIVED" BASIS.

Sample	Total P_2O_5, per cent	Orthophosphate as Na_3PO_4, per cent	Pyrophosphate as $Na_4P_2O_7$, per cent	Triphosphate + Higher Phosphates as $Na_5P_3O_{10}$, per cent
1	57.3	0.4	11.0	89.0
2	57.6	0.7	10.2	89.5
3	56.1	0.4	7.3	89.9
4	56.1	0.5	6.8	90.4
5	57.5	0.5	6.3	93.1
6	57.5	0.4	4.9	94.5
7	57.0	0.0	8.0	91.2
8	57.1	0.0	7.6	91.6
9	56.9	1.6	14.4	83.8
10	56.9	1.1	13.0	85.4
11	56.6	1.8	5.3	91.6
12	56.0	1.2	13.4	83.5

TABLE II.—SAMPLES OF COMMERCIAL TRIPHOSPHATE AS ANALYZED BY METHOD 1 REPORTED ON P_2O_5 BASIS.

Sample	Total P_2O_5, per cent	P_2O_5 as Orthophosphates, per cent	P_2O_5 as Pyrophosphates, per cent	P_2O_5 as Triphosphates + Higher Phosphates, per cent
1	57.3	0.3	10.2	89.9
2	57.6	0.5	9.5	89.9
3	56.1	0.3	7.0	92.7
4	56.1	0.4	6.5	93.2
5	57.5	0.4	5.8	93.7
6	57.5	0.3	4.6	95.1
7	57.0	0.0	7.5	92.6
8	57.1	0.0	7.1	92.8
9	56.9	1.2	13.5	85.2
10	56.9	0.8	12.2	86.9
11	56.6	1.4	5.0	93.6
12	56.0	0.9	12.8	86.3

TABLE III.—EFFECT OF ELUTION RATE ON TRIPHOSPHATE ANALYSIS.

Elution rate, min per 25 ml fraction	Na_3PO_4, per cent	$Na_4P_2O_7$, per cent	$Na_5P_3O_{10}$ by Difference, per cent
2	0.6	8.7	90.4
10	0.5	8.7	90.5
20	0.8	9.8	89.2

TABLE IV.—EFFECT OF QUICK COLUMN REGENERATION ON CONSECUTIVE ANALYSES.

	Na_3PO_4, per cent	$Na_4P_2O_7$, per cent	$Na_5P_3O_{10}$ by Difference, per cent
Fresh Column	0.6	9.0	90.0
After Quick Regeneration of Same Column	0.8	9.7	89.3

A resin bed of 1.5 cm was placed in the auxiliary column. The sample was then introduced into the auxiliary column and the silicates trapped by the resin.

This assembly proved unsatisfactory due to difficulties encountered in maintaining proper heads above the two resins and therefore proper flow rates. Our present assembly was therefore resorted to for this finished product analysis. It was found that the same results were obtained without the need of this auxiliary column. The sample solution is filtered and an aliquot of the filtrate placed on the column. There has been no apparent effect to the resin even after the passage of over 100 samples through the columns.

References

(1) J. Beukenkamp, W. Riemann, and S. Lindenbaum, *Analytical Chemistry*, Vol. 26, p. 505 (1954).

(2) S. Lindenbaum, T. V. Peters, and W. Rieman, *Analytica Chimica Acta*, Vol. 11, p. 530 (1954).

(3) J. A. Grande and J. Beukenkamp, *Analytical Chemistry*, Vol. 28, p. 1497 (1956).

(4) E. Karl-Kroupa, *Ibid.*, Vol. 28, p. 1091 (1956).

(5) R. N. Bell, *Ibid.*, Vol. 19, p. 97 (1947).

(6) R. N. Bell, A. K. Wreath, and W. T. Curless, *Ibid.*, Vol. 24, p. 1997 (1952).

(7) A. J. Mabis and O. T. Quimby, *Ibid.*, Vol. 25, p. 1814 (1953).

(8) H. K. Weiser, *Ibid.*, Vol. 28, p. 477 (1956).

(9) L. E. Netherton, A. R. Wreath, and D. N. Bernhart, *Ibid.*, Vol. 27, p. 860 (1955).

(10) O. T. Quimby, A. J. Mabis, and H. W. Lampe, *Ibid.*, Vol. 26, p. 661 (1954).

(11) T. V. Peters and W. Rieman, *Analytica Chimica Acta*, Vol. 14, p. 131 (1956).

(12) H. K. Weiser, *Journal*, Am. Oil Chemists' Soc., Vol. 34, p. 124 (1957).

Exploratory Fire Tests with Small-Scale Specimens

By HARRY D. FOSTER

A favorable small-scale test can justify the expense of a full scale standard test to establish a fire-resistance rating

BUILDINGS should be fire-safe. The fire resistance of the columns, floors, walls, and other structural elements must be sufficient to withstand the effects of fire originating within or near the building. The fire resistance of a construction or assembly of materials, expressed in hourly ratings, is determined by subjecting the material or a representative sample of the assembly to a test fire of controlled extent and severity. Such test specifications are given in ASTM Standard Methods of Fire Tests of Building Construction and Materials (E 119 – 55).[1]

The standard test rightfully requires large specimens that are representative of the story height and panel size used in buildings. The standard test procedure requires that the length of column exposed to fire be at least 9 ft; that the exposed area of floors be at least 180 sq ft with neither dimension less than 12 ft; and that the exposed area of walls and partitions be at least 100 sq ft with neither dimension less than 9 ft. Test specimens must support a design working load if the assembly is intended for load-bearing use. In addition, they must be subjected to the hose stream test.

Small-scale fire test specimens are usually used in perfecting new materials and construction details before resorting to the standard fire test for establishing acceptable fire-resistance ratings for use in building regulations. This paper points out certain matters which should be observed in making small-scale tests.

Limitations of Small-Scale Tests

Fire tests of small-scale specimens of materials or sections of building members should be limited to exploratory work in perfecting new materials or in determining the effect of fire on varying combinations of new and other well-known materials or assemblies. They may be used to determine the effect of fire on the fire-exposed surface as evidenced by cracking, spalling, depth of burning, etc. They will give comparable data on the temperature rise on the unexposed surface or within the material or assemblies of materials. They do not give reliable data on the effect of attachment or bonding of the parts of an assembly, or the load-carrying ability under fire conditions.

Size of Specimen

The size of small specimens which are intended for development work depends primarily on the nature of the information being sought. In general, the smaller the specimen, the less representative the warping and distortion effects will be to that shown in full-size specimens. The following sizes are the minimum that will yield comparable and reliable information.

Small-scale specimens of a uniform structure throughout, or of two or more different materials laminated together parallel to the surface to be exposed to fire, or of small masonry units, should have the same thickness as that of the proposed construction. The other dimensions of such specimens should be at least six times the thickness but not less than 18 in.

Test specimens of constructions such as studded walls or joisted floors should be not less than three stud or joist spaces wide. The spacing of the studs or joists should be the same as that of the proposed construction since the resistance to fire effects of some plastering bases are related to the distance between their supports.

The depth of the air spaces need not be the same as that in the proposed construction since the flow of heat through the assembly is dependent only in a minor degree on the depth of the air space. A minimum depth of 2 in. is suggested. The dimensions of the air spaces as measured along the studs or joists should be not less than 12 times the depth. The open ends of the air spaces should be sealed with mineral wool or similar insulating material to a thickness at least equal to the depth of the air space.

Small-scale tests of columns and beams are useful only in determining the effectiveness of the fire-protective covering in preventing a critical temperature in the structural material or in its reinforcement. The structural portion of the test column or beam may be one of the smaller columns or beams used for such purposes, but the protective material should be of the thickness intended for the proposed construction. The length of the specimen to be exposed to the fire should be at least five times the least dimension of the protected column or beam. The ends of the test column or beam, whether exposed to fire or embedded in the test furnace structure, should be sealed to provide insulation equal to at least twice that of the protective material encasing the specimen.

HARRY D. FOSTER, associate fire protection engineer with the New York State Building Code Commission, has been a recognized authority on fire testing since 1920. He has been active on ASTM Committee E-5 on Fire Tests of Materials and Constructions for many years and is at present secretary of the committee.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Tentative Revision, 1956 Supplement to Book of ASTM Standards, Part 4, p. 1177; Part 4, p. 215.

Construction of Furnaces

Furnaces for development work may be of the same general types used for standard fire tests, except that means for loading the specimen or for applying the hose stream need not be provided. The details of size and design will be governed by the requisites of size of test specimen, of even distribution of exposing flame, and of burners and vents needed for operation at a slight pressure in the combustion chamber.

Furnaces for testing walls or other specimens such as slabs of materials which are being developed for use as a layer of a composite wall should have an opening in the furnace wall for the test specimen. This opening should be arranged so that the exposed surface of the test specimen can be set flush with the wall of the combustion chamber. Allowance should be made for at least 1 in. of mineral wool or other noncombustible insulating material between the test specimen and the furnace walls. The furnace chamber should be not less than 15 in. deep and should extend not less than 6 in. above, below, and to the sides of the test specimen.

The same general requirements given above for furnaces for testing walls apply for furnaces for testing floors, ceilings, girders, and beams, except that the latter constructions should always be tested in a horizontal position. The furnace chamber under horizontally placed test specimens should be at least 24 in. deep to make it possible to obtain an evenly distributed exposing flame.

Furnaces for testing columns or other structural members encased on all sides with fire-protective materials should have combustion chambers with at least 6 in. clearance on all sides of the test specimen. Unless the burners enter the bottom of the furnace, all portions of the test specimen should be at least 12 in. above the floor of the combustion chamber.

Control of Fire Exposure

The fire exposure should always conform to the well-known standard time–temperature curve defined by the following points:

1000 F	(538 C)	at 5 min
1300 F	(704 C)	at 10 min
1550 F	(843 C)	at 30 min
1700 F	(927 C)	at 1 hr
1850 F	(1010 C)	at 2 hr
2000 F	(1093 C)	at 4 hr

Measurement of Temperatures

The furnace temperatures should be measured with thermocouples enclosed in sealed porcelain tubes, or, in the case of base-metal thermocouples, enclosed in sealed, standard weight, ½-in. black wrought steel or wrought iron pipe. The protected thermocouples should extend at least 12 in. through the furnace walls and have their junctions or ends approximately 2 in. from the exposed surface of the test specimen.

The temperatures within test specimens such as steel columns, girders, or beams should be measured with base-metal thermocouples peened into the steel. Such thermocouples should be placed within the middle third of the exposed length but not closer to the end than 1½ times the least sectional dimension of the test specimen.

The temperatures of the unexposed surfaces of floors and walls should be measured with thermocouples or thermometers placed in contact with the floor or wall surface and under flexible, oven-dry felted asbestos pads about 6 in. square and 0.4 in. in thickness. When thermocouples are used, the wire should not be heavier than No. 18 B & S gage. The thermocouples for unexposed surface should not be placed closer to the edge than 1½ times the thickness of the specimen.

The number of thermocouples will be governed by the size and type of test specimens and the nature of the information desired. It is recommended that the temperatures in the furnace and of the unexposed surface of walls and floors be measured with at least one thermocouple for each 5 sq ft, with a minimum of three thermocouples.

Test Results

The results of small-scale fire tests are useful only in research and development work to prove the adequacy of specific details of an assembly of materials. They will be reliable when the recommendations relative to size, exposure, and methods of measuring temperatures are followed closely. Results from small-scale tests should not be made public but, when favorable, they will serve as justification for the expense of a full-size standard test to establish the fire-resistance rating needed for the promotion and proper use of the new or modified assembly.

Discussion of Paper on Temperatures of Bituminous Roof-Surfaces[1]

D. G. STEPHENSON.[2]—The authors of this paper have presented much information that has a direct bearing on the studies of heat flow through walls and roofs conducted by the Division of Building of the National Research Council of Canada.

The temperature and temperature gradient at the outside surface of a built-up roof are strongly influenced by the surface emissivity. The data reported by Ballantyne and Spencer are useful in showing the magnitude of the temperature reduction that can be achieved by using a white paint on the surface. However, the surface temperature and temperature gradient are also dependent on the roof construction, the heat transfer conditions at the roof surfaces, and the radiation incident on the roof. Thus the data reported by Ballantyne and Spencer are specific to the conditions which they obtained for their tests and cannot be used to calculate the temperatures for other types of roof or even for the same type of roof in a different climate. It is unfortunate that they did not expand their investigation to include measurements of the solar absorptivity and long wave-length emissivity for each of the surfaces tested so that it would have been possible to calculate outside surface temperature and heat flow for any solid roof with a similar coating.

This calculation is greatly simplified by the use of sol-air temperature since it combines heat transfer by radiation and convection into one equivalent process. The sol-air temperature concept was first used by Mackey and Wright[3] who define sol-air temperature as "the temperature of the outdoor air which, in contact with a shaded wall, would give the same rate of heat transfer and the same temperature distribution through the wall as exist with the actual outdoor air temperature and incident solar radiation."

Parmelee and Aubele[4] showed that the exchange of energy by long wave-length thermal radiation was also significant and could be included in the

[1] E. R. Ballantyne and J. W. Spencer, "Temperatures of Bituminous Roof Surfaces," ASTM BULLETIN, No. 223, July, 1957, p. 69 (TP135).

[2] Building Services Section, National Research Council of Canada, Division of Building Research, Ottawa, Canada.

[3] C. O. Mackey and L. T. Wright, "The Sol-Air Thermometer—A New Instrument," *Transactions*.Am. Soc. Heating and Ventilating Engrs., Vol. 52, p. 271 (1946).

[4] Parmelee and Aubele, "Radiant Energy Emission of Atmosphere and Ground," *Ibid*, Vol. 58, p. 85 (1952).

sol-air temperature. In addition to surface emissivity and absorptivity, sol-air temperature depends on the following meteorological data: solar radiation on a horizontal surface, air temperature, dew point temperature, and wind velocity.

The temperature and temperature gradient at the outer surface of a solid roof can be calculated for any periodic sol-air temperature by the method described by Mackey and Wright.[5,6]

A simpler method for composite walls or roofs, developed by the writer, has been used to calculate the values presented in Table VI, for the surface temperature and heat flow for an insulated concrete roof (*a*) with the insulation on the inside and the waterproofing membrane on the outside of the concrete, and, (*b*) with the insulation between the concrete and the waterproof layer. With the first arrangement, the maximum surface temperature and rates of change of temperature are lower than in the second arrangement which has a lower maximum temperature gradient. Ballantyne and Spencer suggest that both high temperature and high rates of change of temperature may cause serious deterioration of bituminous roof membranes. A large temperature gradient through the roof membrane might also accelerate roof deterioration. This deterioration can be reduced by proper design of the roof if it can be established which condition is most serious.

A. W. Attwooll.[7]—We have read with interest the article by Ballantyne and Spencer. We thought it might add to the sum total of information on this subject if we gave certain data which have been obtained in England.

Although some work has been carried out at temperatures obtained with bituminous felt roof coverings, as, for instance, the work of H. E. Beckett[8] which the authors cite, we have confined our examination to mastic asphalt roof coverings which are hand-laid $\frac{3}{4}$ in. or 1 in. in thickness.

The work was instituted some years ago because of certain misconceptions and statements which were made to the effect that one of the disadvantages of dark colored roof coverings was that the temperature in the concrete attained a higher figure when such materials were employed than would be the case if no roof covering were used.

TABLE VI.—SURFACE TEMPERATURE AND HEAT FLOW FOR AN INSULATED CONCRETE ROOF.

The roof is assumed to have constant inside and outside film coefficients of 1.65 and 6.00 Btu per sq ft per hr deg Fahr, respectively.
Inside air temperature is assumed constant at 75 F.

Time, hr	Sol-Air Temperature for Dark Horizontal Surface, deg Fahr[a]	4 in. Concrete Roof Deck 2 in. Insulation Inside		4 in. Concrete Roof Deck 2 in. Insulation between Deck and Roof Membrane	
		Surface Temperature, deg Fahr	Heat Flow into Roof, Btu per sq ft per hr	Surface Temperature, deg Fahr	Heat Flow into Roof, Btu per sq ft per hr
Midnight	78.8	82.2	−20.4	78.7	+ 0.6
1	76.9	80.1	−19.2	76.8	+ 0.6
2	74.5	77.9	−20.4	74.6	− 0.6
3	72.6	75.9	−19.8	72.7	− 0.6
4	72.7	74.8	−12.6	72.8	− 0.6
5	75.2	75.2	0.0	75.4	− 1.2
6	81.3	78.1	+19.2	81.2	+ 0.6
7	90.9	83.9	+42.0	90.3	+ 3.6
8	103.3	92.1	+67.3	102.0	+ 7.8
9	116.7	102.0	+88.3	114.7	+12.0
10	129.0	112.7	+97.8	126.8	+13.2
11	138.7	122.6	+96.7	136.2	+15.0
Noon	144.0	130.2	+82.9	141.4	+15.6
1	144.1	134.3	+58.8	141.8	+13.8
2	139.1	134.7	+26.4	137.4	+10.2
3	130.2	131.5	− 7.8	129.3	+ 5.4
4	119.3	125.2	−35.4	118.8	+ 3.0
5	107.8	117.2	−56.4	107.8	0.0
6	97.5	108.7	−67.3	98.0	− 3.0
7	89.7	100.9	−67.3	90.3	− 3.6
8	84.7	94.5	−58.8	85.2	− 3.0
9	82.1	89.8	−46.1	82.4	− 1.8
10	80.6	86.5	−35.4	80.8	− 1.2
11	79.9	84.2	−25.8	79.9	0.0

[a] The sol-air temperature is given by the equation $t_{SA} = 100.4 - 33.6 \cos(15\,\theta - 14 \text{ deg}) + 11.05 \cos(30\,\theta - 6.4 \text{ deg})$ which is the mean value plus the fundamental and first harmonic of the design sol-air temperature given in ASHAE guide for a dark horizontal surface.

Some preliminary experimental work was carried out in the 1930's by the Building Research Station, and in constructing a new roof at our laboratory we had thermocouples installed which enabled us to carry out long-period tests under strictly practical conditions on areas of asphalt roof covering of appreciable size. Results obtained during the years 1938-1939, are given below and in Table VII: it will be noted that they support the view we have held and, generally speaking, confirm the information published by the authors and the conclusions they have drawn.

1. While the readings during winter months show some anomalies, the true insulating properties are only apparent during hot weather and the findings are based on these readings with the exception of the conclusions stated under paragraph 2.

2. The value of a tile is shown during both summer and winter months. Temperatures in the concrete are higher than in the asphalt during the winter, indicating that a roof covered with asphalt and a tile have an insulating value and retard the outflow of heat from the building through the roof structure.

3. While during hot weather the temperature in exposed asphalt surfaces is higher than the "sun" temperature, indicating absorption and a "build-up" due to color, the concrete underneath is cooler and does not get hotter than when it is exposed. This is in support of previous claims made and does not agree with certain opinions expressed in the past by others.

4. Surface treatments and tiles all have a high insulating value with respect to asphalt and concrete during hot weather. Despite the greater mass of the tiles the reflective value of Spar treatment is most marked. During the hottest days of June and July the Spar treatment showed a reduction of 13 C in the asphalt and 11.5 C in concrete by comparison with an untreated section of roof; and 9 C and 4 C in asphalt and concrete by comparison with exposed concrete.

Mr. E. R. Ballantyne (*authors' closure*).—The authors are grateful for the contribution of Messrs. Stephenson and Attwooll to the discussion. The work described in the paper was undertaken as part of a study on the deterioration of bituminous roof surfaces and was not designed to assist in studies of heat flow through roofs. However, a sol-air thermometer to the design of Mackey and Wright[3] was set up and the temperature of a black surface on its u per horizon-

[5] Mackey and Wright, "Periodic Heat Flow—Homogeneous Walls or Roofs," *Ibid*, Vol. 50, p. 293 (1944).

[6] Mackey and Wright, "Periodic Heat Flow—Composite Walls or Roofs," *Ibid*, Vol. 52, p. 283 (1946).

[7] Executive technical director, The Limmer and Trinidad Lake Asphalt Co., Ltd., London, England.

[8] H. E. Beckett, "The Exclusion of Solar Heat—II—Flat Roofs," *Journal*, Inst. Heating and Ventilating Engrs., Vol. 3, p. 79 (1935–1936).

TABLE VII.—ROOF HEAT INSULATION RESULTS. TRINIDAD WHARF, FULHAM—1938–39.

		Oct. 31, 1938	Nov. 28, 1938	Dec. 29, 1938	Jan. 6, 1939	Jan. 12, 1939	Feb. 20, 1939	March 30, 1939	April 27, 1939	May 26, 1939	June 7, 1939	July 11, 1939	Aug. 18, 1939
Natural rock asphalt mastic (1)	Max. asphalt temperature, deg Fahr	54	44.5	38	43.7	34.7	53.7	62.6	66.2	85	119.3	102.2	100.4
	Max. concrete temperature, deg Fahr	49	44	38.3	43.7	38.3	49	57.7	57.2	81.5	106.7	95	91.4
Natural rock asphalt mastic (2)	Max. asphalt temperature, deg Fahr	54	44.5	38	43.7	34.7	53.7	62.6	66.2	85	119.3	102.2	100.4
	Max. concrete temperature, deg Fahr	51	45.7	41	38.3	38.3	49	59.0	57.7	81.5	105	95	91.4
Limestone mastic asphalt (1)	Max. asphalt temperature, deg Fahr	...	...	...	...	...	...	...	...	...	...	...	...
	Max. concrete temperature, deg Fahr	49	45.5	41	41	41	45.6	54.5	57.2	81.5	105	95	91.4
Limestone mastic asphalt (2)	Max. asphalt temperature, deg Fahr	54	44.5	38	43.7	34.7	53.7	62.6	66.2	84.2	119.3	102.2	100.4
	Max. concrete temperature, deg Fahr	...	...	...	...	...	...	...	...	...	...	...	...
Asphalt treated with white spar	Max. asphalt temperature, deg Fahr	48.5	42.4	37	44.5	33.8	43.7	49	44.6	74.3	95	84.2	82.5
	Max. concrete temperature, deg Fahr	47	43.7	39.2	38.3	39.2	40	48.2	44.6	70.7	86	78.8	78.8
Asphalt treated with white paint	Max. asphalt temperature, deg Fahr	...	...	...	...	...	...	...	...	...	...	...	...
	Max. concrete temperature, deg Fahr	46.5	44.5	...	32.9	41.9	0.00	50	50	70.7	87	82.5	78.8
Asphalt and protective tile	Max. asphalt temperature, deg Fahr	44.5	42.8	37.4	39.2	33	53.7	50.9	50	74.3	96.8	87.8	85.
	Max. concrete temperature, deg Fahr	46.5	45.5	39.2	35.6	36.8	57.5	51.8	53.7	74.3	95	85	82.4
Asphalt and insulating tile	Max. asphalt temperature, deg Fahr	44.5	43	38.3	39.2	38.3	46.4	44.6	46	71.6	90.5	84.2	80.6
	Max. concrete temperature, deg Fahr	47	43.5	37.4	41	41	48.2	53.7	53.7	74.3	95	85	82.4
Exposed concrete	Temperature, deg Fahr	...	...	...	...	...	...	...	0.00	77	111.2	95	95
Sun temperature, deg Fahr	.....	55.5 Dry Dull	50.3 Wet Cloudy	48.2 Dry Bright	36 Bright	48.5 Dry Bright	62.7 Dry Bright	58.7 Dry Bright	53.6 Showery	68.0 Dry Dull	97 Dry Bright	79.7 Dry Bright	83.8 Dry Bright

tal face recorded for a portion of the time during which the experiment was in progress.

The temperatures recorded on the sol-air thermometer were consistently lower than on a similar black surface on a roof. The difference was sometimes greater than 10 F and is attributed to a size effect. The black roof surface covered a considerably larger area than the surface on the sol-air thermometer, and the layer of air above it was heated to a temperature considerably above general air temperature, whereas the layer of air above the much smaller sol-air thermometer did not increase in temperature to the same extent. That the air above the roof surface was at a higher temperature than the general air temperature was shown by drawing it off past a thermometer. Hence to the factors on which sol-air temperature is dependent, as given by Stephenson, should be added the area of the surface.

The temperatures recorded on the roof would thus be closer approximations to sol-air temperatures than those recorded by a sol-air thermometer, and the true sol-air temperature would be higher again. A better approximation could probably be calculated, assuming a steady state condition, from the relation

$$\frac{t_{SA} - t_i}{R_T} = \frac{t_m - t_i}{R_T - R_{SO}}$$

where:

t_{SA} = sol-air temperature,
t_i = temperature of air below the timber deck (assumed equal to the air temperature as recorded),
t_m = temperature of roof surface,
R_T = total thermal resistance, and
R_{SO} = external surface resistance coefficient.

Sol-air temperatures for surfaces other than those examined could be calculated if the solar absorptivity and long wavelength emissivity of the various surfaces were known. Values of these characteristics taken from a review of the literature by Holden and Greenland[9] should be sufficiently accurate for this purpose. These are given in Table VIII.

TABLE VIII.—SOLAR ABSORPTIVITY AND LONG WAVE-LENGTH EMISSIVITY OF THE VARIOUS SURFACES.

Surface	Solar Absorptivity	Long-Wavelength Emissivity
Black, bituminous	0.9	0.9
Aluminum paint	0.5	0.3
Aluminum foil	0.15	0.05
White	0.3	0.9

Stephenson examines the temperatures, rates of change of temperature, and temperature gradients for a concrete roof with insulation in the two alternative positions inside and outside the concrete, and suggests that a large temperature gradient through the roof membrane may cause serious deterioration. The authors are of the opinion, however, that high surface temperature is probably a more serious cause of deterioration. Nevertheless, it is probably best to have the insulation on the outside of the concrete. This condition gives rise to higher surface temperatures than otherwise, but on the other hand reduces the maximum temperature reached by the concrete. This is highly desirable for two reasons: first, the chances of structural cracking are thereby reduced, and second, the water vapor pressures in a roof deck that has not been thoroughly dried out are reduced. This in turn reduces the risk that blisters will occur in the membrane.

[9] T. S. Holden and J. J. Greenland, "The Coefficient of Solar Absorptivity and Low Temperature Emissivity of Various Materials," Commonwealth Scientific and Industrial Organization, Australian Division Building Research Report. (1951).

*Trends and Outlook for Technological Progress from the Standpoint of the Research Scientist**

By B. D. THOMAS, *Director*, Battelle Memorial Institute

SCIENCE and technology are represented in the public mind today by satellites, rockets, and missiles, but fortunately for the people of the United States there is much other fine work going on in the nation's laboratories. Ideas continue to pour out to save human lives, to insure bountiful food supplies, to speed communications and transportation, to reduce manual labor, and to increase our standard of living.

The supply of scientific facilities and trained manpower is not unlimited in any country. Each country must make a choice as to what it does with its scientific resources. The decisions the United States makes may well be of surpassing importance in determining the future of this country. Against the regimented and calculated scientific effort of a dictatorship, we oppose the ideas of men who enjoy a greater freedom in their scientific research.

The decisions about our scientific effort must be made on the basis of an understanding of the real place of science and technology in our industrial complex. Our modern industry is a product of two factors: knowledge of what to do and the will to do it. The first factor is supplied by scientists and engineers; the second by industrial enterprise. The United States has been strong militarily and economically because it has possessed both of these factors in abundant measure. We will continue to be strong by taking actions that encourage scientific and technological progress and industrial enterprise.

Our country must make a choice in the way it wishes to support and utilize science and technology. It must decide the way in which technology and industrial enterprise are to be brought together. These decisions are basic not only to our military security, but to our economic welfare—and, in a very real sense, our military security is founded on our economic power.

Our supply of technological manpower is limited; it is important that it be used to best advantage. Our research facilities are limited; it is important that they be used to best advantage. It can hardly be said that we have as yet come to grips with our problems. We have not put into our social and economic system the incentives that will attract young people to science; we have not fully recognized the need for research facilities and equipment.

The primary need is to create and maintain an atmosphere in which science and technology will grow and continue to contribute intellectual and material benefits to our national life. Foremost, this is the responsibility of the Federal Government. It is the largest spender in the field, and its research policies are of fundamental importance in the scientific effort of the country. These policies should be better established and understood. There is need for more stability in the Federal research programs. The recent curtailment is a case in point; the damage to research morale was greater than the value of dollars saved. Stability is of as great importance as the actual magnitude of expenditures.

The policies of the Federal Government should encourage research in industry. This may be accomplished by tax legislation to encourage research and industrial progress. The country would gain if our tax laws contained provisions which made it advantageous to industry—particularly small industry—to do scientific research.

Financial incentives, but not financial incentives alone, are needed to attract talented young men and women into science. Our basic educational policies are a factor; the salaries paid public school teachers are a national disgrace, although this situation is improving. The tendency to depict scientists in a derogatory way is extravagant by-play we can ill afford while we are in competition with a hostile power that places science on a pedestal.

There is pressing need for more public appreciation of the role of science and technology in our economy. This must be built up through education and sympathetic support of all elements in our society.

* Summary of statement before subcommittee on Economic Stabilization of the Joint Economic Committee, Congress of this United States, on November. 14, 1957.

(*Continued from page 27*)

of the radioisotopes. For some uses one or two weeks of training is sufficient. However, for an extensive program of research and application with isotopes, a company may wish to have a supervisor trained for several months in the broad principles of the use of radioisotopes.

Another deterrent, I think, is management. Management in general has to be sold on at least two things. One is to overcome inertia to go into something new. They have to understand the economic advantages as well as other advantages. Also, they usually worry about the disadvantage of having radioactive materials in their plant. This problem may be overcome by public relations programs to show that these materials do not represent a serious hazard, that they are used in many plants throughout the country, and in Atomic Energy Commission installations the safety record has been excellent indeed.

Then, of course, there is a third item, the matter of setting up standards for industry or standards of testing. A major role of ASTM Committee E-10 has been advising the Society and other committees on tests that could become standard. Committee E-10 has been active or "radioactive," in this field, but other committees have not been so highly activated. This inducing of radioactivity in the other committees has not taken place to any great extent. Tests demonstrated here could be taken over by other committees and standardized and specifications could be set up. Many tests could become accepted as routine.

At any time we would be glad to answer questions concerning policies of the Atomic Energy Commission. It would take too long here to go into all the different phases. I can say this, however, that in our program for making available not only radioactive by-products but also uranium, fissionable materials, and all the other hazardous materials of atomic energy, the system of controls consists of licensing, regulations and inspection. Hazardous materials or devices or facilities must be covered by a license. The conditions of a license vary a great deal, from a facility with very little hazard to a large power reactor.

In addition to licensing, there are also regulations. There are regulations, for example, on health and safety—that is, how much exposure people can safely take to certain forms of radiation, and certain control procedures in maintaining security of the radiation sources. I do not mean military security, but just physical security so that the radioactive sources do not get lost. Lastly, there are controls by an inspection system for those kinds of materials and those kinds of facilities that represent a substantial public hazard. Licensees will be visited from time to time to see if they are operating safely; the visitor acts not only in the role of inspector but perhaps more in the role of an educator, to see that the facilities are being used in the public interest in health and safety.

The Bookshelf

Handbuch der Sonderstahlkunde

Eduard Houdremont, in collaboration with Hans-Joachim Wiester, 3rd Ed., Springer-Verlag, Berlin/Göttingen/Heidelberg; Verlag Stahleisen m.b.H., Breite Strasse 27, Düsseldorf 22a, Germany; 1538 pp., DM 220 (about $52.50).

THE third edition of the *Handbook of Special Steel Metallurgy* represents an extensive revision of Professor Houdremont's second edition which appeared in 1943. This classic is the standard for European metallurgists, and, in the reviewer's opinion, is unequalled by any English text in the scope and authority of its treatment. It is an authoritative and complete yet concise review, summary, and tabulation of the important facts about special steels—from both the theoretical and practical standpoints. Since special steels are taken to include all those steels which require either special composition, production, or treatment, the scope of the book is extremely broad. The work is divided into three main sections entitled, respectively, Pure Iron, Iron-Carbon Alloys, and Alloy Steels.

Pure iron falls into the category of a special steel since special methods are necessary for its production. An unusually effective device employed by Houdremont and Wiester is that of introducing background information on a subject the first time it is mentioned. Thus, when dealing with elastic and plastic deformation, they introduce the basic concepts of dislocation theory; in their discussion of recovery and recrystallization, they draw upon results obtained with aluminum; the thorough review of magnetic properties includes much on basic theory; the treatment of subjects such as electrical conductivity and chemical properties includes electronic structure and binding, oxidation, and corrosion theory.

Iron-carbon alloys are considered in terms of their structures, transformations, property changes upon tempering, etc. The practical applications of the iron-carbon phase diagram are discussed for iron-carbon alloys, then extended to include tool steels and structural steels. An excellent review of transformation is presented in terms of the pearlite, intermediate, and martensitic phases. Not only are the essential features of the formation and characteristics of these products clearly stated, but the more advanced and recent findings are competently surveyed as well. For example, the numerous contributions of Prof. Morris Cohen and his students at MIT are treated in detail. Russian work in this field is also reported here, but, oddly enough, very little reference is made to Russian contributions in the rest of the book. Over 200 pages are devoted to the practical aspects of annealing, hardening, and tempering. Such items as hardenability, case hardening, recovery, and recrystallization, temper brittleness, and heat treatments are well handled.

The remainder of the two volumes is devoted to a systematic examination of alloy steels, but several general topics are treated first. Classification schemes of iron-base binary phase diagrams, atomic radii, electronic structures, thermodynamic considerations, ternary diagrams, carbide characteristics, etc., are summarized. Then the authors proceed to a discussion of alloy steels under the heading of the main alloying ingredient—in great detail for some 20 of the more important alloying elements, and to a lesser extent for the less common additions, such as the rare earths and the noble metals. Tool and structural steel applications are covered for most alloys, and, in addition, other uses for each particular steel are given. Over 250 pages are devoted to almost every conceivable aspect of the physical metallurgy of alloy steels containing chromium; about 150 pages, to cobalt-containing alloys; etc., down to 4 pages on steels with boron. In view of the extensive survey articles that have appeared elsewhere lately, it is surprising that the section on alloy steels with columbium and tantalum has remained practically unchanged from the second edition.

To give a proper appreciation of the detailed treatment accorded even one alloy steel would require more space than is available here. However, Houdremont and Wiester's handbook rises far above a mere listing of properties or tabulation of data, although such information appears when needed. Instead, they have given a definitive survey of the present state of knowledge on almost every phase of physical metallurgy. Thus, the research worker will find each topic completely satisfactory for orientation or review purposes; the engineer will have technical information on special steels presented in a useful, logical manner; while the student will see the myriad of elements of physical metallurgy in their proper perspective, not only with regard to each other, but also from the standpoint of the practical problems involved. This handbook may be recommended to the American metallurgist without reservation.

ERVIN E. UNDERWOOD

PROFESSIONAL CARDS

Commercial Testing, Research, and Services

- Chemical
- Metallurgical
- Physical
- Radiographic
- Spectrographic
- Sampling

CHARLES C. KAWIN COMPANY
METALLURGICAL CHEMISTS
FOUNDRY and METALLURGICAL ENGINEERS
METALLOGRAPHERS—SPECTROGRAPHERS
PHYSICAL TESTS
431 S. Dearborn St. Chicago 5, Ill.
P.O. Box 2035 Buffalo 5, N. Y.
Member: American Council of Independent Laboratories

ABBOT A. HANKS, Inc.
Established 1866
Engineers—Chemists—Assayers—Samplers
Spectrographers;
Inspection—Tests—Consultation—Research
Member: American Council of Independent Laboratories
624 Sacramento Street, San Francisco 11, California

MILLION VOLT X-RAY SERVICE
also
Low Voltage X-ray, Gamma-ray, Magnaflux, Zyglo, Ultrasonics, Impact, Chemical, Metallography, Physical, Hardness, Stress Rupture Tests.
Laboratory and Field Testing and Inspection.
ARNOLD GREENE & CO., INC.
122 Hampshire Street, Cambridge, Massachusetts
University 4-8800

SOUTHERN LABORATORIES, INC.
Engineers—Chemists
Sub Soil Investigations
Physical, Chemical, and Soil Laboratories
Research & Inspection
Complete Model Shop
Mobile, Alabama New Orleans, La.

LEHIGH TESTING LABORATORIES
P. O. BOX 1241 WILMINGTON, DEL.
Analysis
Research
Development
Investigations
Spectrography
Physical Testing
Salt Spray
Radiography

Container and Material Testing
THE DON L. QUINN COMPANY
224 West Kinzie Street
Chicago 10, Ill.
Independent tests, studies, surveys, and consultations
Member: ASTM, TAPPI, FPRS

ELECTRON • X-RAY • LIGHT
MICROSCOPY
full **CONSULTING** service
ERNEST F. FULLAM, Inc.
ELECTRON, X-RAY & LIGHT Microscopy
CONSULTING IN INDUSTRIAL DEVELOPMENT, CONTROL, RESEARCH
P.O. BOX 444, SCHENECTADY 1, N.Y.

JOSEPH S. WARD, INC.
SOIL TESTING LABORATORY
Identification and Strength Tests on Soils, Field Supervision, Reports, Consultation.
91 Roseland Avenue
Caldwell, N. J.
Tel. CAldwell 6-9191

CHEMICAL & ENGINEERING CONSULTANTS
Research, process and product development, plant design, nuclear and surface chemistry, analyses, bacteriology, toxicology, organic syntheses, market surveys.
SNELL FOSTER D. SNELL, INC.
29 W. 15th St., N.Y. 11, N.Y.
Telephone: WAtkins 4-8800
Member: American Council of Independent Laboratories

LUCIUS PITKIN, INC.
ESTABLISHED 1885
Metallurgical Chemists & Consultants
Emission & X-Ray Spectrographic Analysis—High-Temp. Tensile & Stress Rupture Testing of High Temperature Alloys
PITKIN BLDG. 47 FULTON ST., N.Y. 38, N.Y.
Member: American Council of Independent Laboratories

John W. McBurney
Consultant on Masonry, Masonry Materials and Plaster
P. O. Box 901 Silver Spring, Md.
JUNIPER 5-3504

COMMERCIAL LABORATORY FACILITIES
FOR NON-DESTRUCTIVE TEST • X-Ray (250 KVP) • Gamma Ray • Magnaflux • Brinell or Rockwell Hardness FOR STATIC TEST • 1,000,000 lbs. Universal Machine FOR DYNAMIC TEST • 9,000 lb. Drop Hammer FOR FATIGUE TEST • 60,000 lb. Life Test Machine FOR IMPACT TEST • Izod or Charpy Specimens (room or sub-zero temperatures) FOR STRESS ANALYSIS • Stress Coat • Strain Gauge Static & Dynamic Equipment
YOUR INQUIRIES WILL BE GIVEN PROMPT ATTENTION
THE SYMINGTON-GOULD CORPORATION
DEPEW, NEW YORK PHONE REgent 6000

Herron Testing Laboratories, Inc.
Analysis — Testing — Inspection
Chemical Physical
Radiographic Metallurgical
Subsoil Evaluation — Concrete Control
1360 W. 3rd Street, Cleveland 13, Ohio
122 Clinton Street, Buffalo 3, N. Y.
Member: American Council of Independent Laboratories

THE MOST EXPERIENCED
FILM BADGE SERVICE
ST. JOHN X-RAY LABORATORY
Califon, New Jersey
Established 1925

SMITH-EMERY COMPANY
Established 1910
Chemists — Engineers
Sampling, Analyzing, Assaying
Spectrography, Physical Testing
Member: American Council of Independent Laboratories
781 E. Washington Blvd. Los Angeles 21, Calif.

GRAHAM, SAVAGE & ASSOCIATES, Inc.
Consulting—Engineering—Research
Electroplating and Metal Processing
Waste Treatment and Production Problems
Surveys—Designs—Specifications
475 York Rd. Jenkintown, Pa.
Also: Kalamazoo—New York

LEDOUX & COMPANY, INC.
Chemists, Assayers, Engineers
Samplers and Weighers
Spectroscopists
359 ALFRED AVENUE
TEANECK, NEW JERSEY
Member: American Council of Independent Laboratories

RESEARCH
DEVELOPMENT
QUALITY CONTROL
DTL
554 BAGLEY
PHONE WO 1-4878
DETROIT 26, MICH.
THE DETROIT TESTING LABORATORY, INC.

PROFESSIONAL CARDS

INTERNATIONAL TESTING LABORATORIES, INC.
METALLURGISTS—CHEMISTS
CHEMICAL ENGINEERS
SPECTROGRAPHIC ANALYSIS
CHEMICAL AND PHYSICAL TESTING
METALS—ORES—PLASTICS—RUBBER—PAINTS
PAPER—FUEL
METALLURGICAL INVESTIGATIONS
ENVIRONMENTAL TESTING
578-582 Market St., Newark 5, New Jersey

CARL BUSSOW
Consulting Chemist and Paving Engineer
Specialist on
Asphalt, Petroleum and Tar Products
801 Second Ave. New York 17, N. Y.

STILLWELL & GLADDING, INC.
Inspection-Sampling-ANALYSIS of Chemicals, Drugs, Fats, Greases, Oils, Waxes, Fertilizers, Glycerine, DDT., B.H.C., Chlordane, etc., Pyrethrum, Rotenone Products, Soaps, Solvents, Tests, AOAC., ASTM., NF., USP., Tobacco **Est. 1868**
130 Cedar Street, New York 6, N. Y.

COLOR STANDARDIZATION AND QUALITY CONTROL
Materials & Techniques
Visual Color Standards and Color Measurement
MUNSELL COLOR COMPANY, INC.
10 E. Franklin Street, Baltimore 2, Maryland

Omaha Testing Laboratories
Chemists, Testing and Inspection Engineers
Testing, Inspection, Consultation, Design of all types of building and paving materials.
Investigation of Foundation Soils
511 South 20th St. Omaha 2, Nebraska

ST. LOUIS TESTING LABORATORIES
2317 CHOUTEAU AVE. • ST. LOUIS 3, MO.
CHEMICAL, PHYSICAL, METALLURGICAL
TESTING AND INSPECTION OF MATERIALS
X-RAY AND GAMMA RADIOGRAPHY
C. D. TROWBRIDGE, DIRECTOR — CENTRAL 1-0929, CENTRAL 1-7585
Member—American Council of Independent Laboratories

PELMOR LABORATORIES INC.
TESTING — RESEARCH
DEVELOPMENT — CONSULTING
BASIC MATERIALS TO END PRODUCTS
RUBBER, PLASTICS, ELASTOMERS, SILICONES
COMPOUNDING, FORMULATION
ANALYSIS, MOLD DESIGN
PROCESSING & METHODS
401 Lafayette St. Newtown, Pa.

RESEARCH • TESTING • DEVELOPMENT
in engineering, chemistry, metallurgy, textile technology, electronics, microbiology and psychometrics . . . from basic materials to finished products.
UNITED STATES TESTING COMPANY, Inc.
Hoboken, N. J.
BOSTON • BROWNSVILLE • DALLAS • DENVER
LOS ANGELES • MEMPHIS • NEW YORK
PHILADELPHIA • PROVIDENCE • SAN ANGELO

DESERT SUNSHINE EXPOSURE TESTS
7740 Ramona Road
Phoenix, Arizona
WE TEST ANYTHING UNDER THE SUN

Chicago Spectro Service Laboratory
Spectrographic and Chemical Analysts—Metallurgists
QUANTOMETER METAL ANALYSES
2454 W. 38th St. Chicago 32, Ill.

Europe
KONING & BIENFAIT
Testing Laboratories of Building Materials
Consulting Engineers — Metallurgists — Chemists
Inspection — Sampling — Testing — Analysis
Research — Development — Control
Coal, Oils, Fats, Waxes, Cement, Concrete, Steel, Water, Gases, Solvents, Paints, Ores. Established 1890
104 Decostakade. Amsterdam-W. P.O. Box 6005

ELECTRICAL TESTING LABORATORIES, INC.
2 East End Avenue, New York 21, N.Y.
Electrical, Electronic, Environmental, Photometric and Chemical Laboratories.
Testing, Research, Inspection and Certification

WESTCHESTER TESTING COMPANY, INC.
M. C. Tomasetti, PE., *Director*
Consulting Engineers • Chemists
FOUNDATIONS—PAVEMENTS
Designs, Evaluations • Supervision, Reports
TESTS—INSPECTION—BORINGS—SURVEYS for Expressways—Airfields—Structures
Domestic and Overseas Operations
34 Weyman Ave., New Rochelle, N. Y.

PENNIMAN & BROWNE, INC.
CHEMICAL & PHYSICAL TESTING-RESEARCH
Soils Investigation—Field X-Ray
Concrete Design & Control—Steel Inspection
COAL SAMPLING AND ANALYSIS
Philadelphia—Baltimore—Hampton Rds.
Member: American Council of Independent Laboratories
341 St. Paul Pl., Baltimore 2, Md.

ARIZONA TESTING LABORATORIES
Chemists—Assayers—Engineers
Chemical & Spectrographic Analysis
Physical Tests—Inspection
Soil Investigation—Sampling
Outdoor Weathering Tests
817 W. Madison, Phoenix, Arizona
Member: American Council of Independent Laboratories

Cable "Seyboltoil" All Standard Codes—Specify
TANK STRAPPING
E. W. SAYBOLT & CO.
INSPECTORS OF PETROLEUM
Licensed by New York Produce Exchange
265 Bayway, Elizabeth 2, N. J.
Dependable Inspection Service at All Points
Bulk Cargo Inspection Our Specialty
Laboratories and Offices in important cities.

Raymond B. Osborne LABORATORIES, INC.
Testing and Inspection Engineers
1907—1957
RICHMOND 9-3111
235 WEST TWENTY-SEVENTH STREET
LOS ANGELES 7, CALIFORNIA

HALES TESTING LABORATORIES
ENGINEERS • CHEMISTS • METALLURGISTS
OAKLAND HALES TESTED SAN JOSE
4514 HOLLIS ST. • OAKLAND 8, CALIFORNIA

The Haller Testing Laboratories, Inc.
140 Cedar Street, New York 6, N. Y.
Testing—Inspection—Consultation
Concrete—Asphalt—Steel
Soil Borings—Soils Laboratory
New York, Plainfield, N. J. — Boston, Mass., New Haven, Conn.

SOUTHWESTERN LABORATORIES
Consulting, Analytical Chemists and Testing Engineers
Inspections; Testing and Chemical Work
Fort Worth, Dallas, and Houston, Texas
Member: American Council of Independent Laboratories

CHEMISTS • INSPECTORS • ENGINEERS
. . . serving commerce and industry
Facilities for inspection, testing, analysis and research of all types.
Write for brochure
The BOWSER-MORNER Testing Laboratories, Inc.
P. O. Box, 51, Dayton 1, Ohio
Member: American Council of Independent Laboratories

PROFESSIONAL CARDS

CHEMISTS, ENGINEERS & INSPECTORS
Coal—Coke—Petroleum Products
Commercial Testing & Engineering Co.
228 N. La Salle St. Chicago 1, Ill.
Charleston, W. Va. Toledo, O. Cleveland, O.
Terre Haute, Ind. Norfolk, Va.
Member: American Council of Independent Laboratories

Associated Laboratories
Professional Engineers—Chemists
C. A. Lashbrook Owner-Director
Soils Investigations—Coring
Physical Testing—Chemical Analysis
2920 Oak Kansas City, Mo.
Member: American Council of Independent Laboratories

EXPOSURE TESTING
Sunlight - Weathering - Corrosion. Direct - Underglass Exposures, Inland-Seashore-Tidal Sites, Chemical-Biological-Physical Testing, Research-Development
APPLIED RESEARCH LABORATORIES of Fla. Inc.
CHEMISTS—ENGINEERS
P. O. BOX 593 MIAMI SPRINGS, FLA.

PATZIG TESTING LABORATORIES
ENGINEERING INSPECTION
TESTS • ANALYSIS • RESEARCH
—OF—
EQUIPMENT • APPLIANCES
MATERIALS & PRODUCTS
Ingersoll Ave. & 23rd St. Des Moines, Iowa
Member: American Council of Independent Laboratories

SOIL TESTING SERVICES, INC.
Soil Investigations
Laboratory Testing
Engineering Reports
& Recommendations
Chicago: Milwaukee: Portland, Michigan:
San Francisco: Kenilworth, New Jersey: Havana, Cuba

Request Brochure and Publication CHEMISTRY IN ACTION, on letterhead

TRUESDAIL LABORATORIES, INC.
Chemists, Engineers, Bacteriologists
4301 No. Figueroa Street, Los Angeles 65, California CA 6-4160
HAWAIIAN DIVISION Honolulu, Hawaii

Research — Consultation — Analyses — Testing

SHILSTONE TESTING LABORATORY
Chemists & Engineers
Spectrographic Analyses*
New Orleans, La. *Houston, Tex.
Inspection at all leading industrial centers
Member: American Council of Independent Laboratories

Water Service Laboratories, Inc.
Specialists in Water Treatment
Main Office: 423 W. 126 St., N. Y. 27, N. Y.

South Florida Test Service
Testing • Research • Engineeer
Consultants and specialists in corrosion, weathering and sunlight testing.
4201 N. W. 7th Street Established
Miami 44, Fla. 1931
Member: American Council of Independent Laboratories

PORE SIZE DETERMINATIONS
Complete pore spectra by mercury intrusion, 1000 to 0.1 micron diameter. All materials: ceramics, metals, plastics, carbon. Filters, catalyst carriers, structural materials, electrodes, separators, etc.
PRADO LABORATORIES
P. O. Box 2607 Cleveland 7, Ohio
Write for explanatory literature.

The Oldest Commercial Laboratory In America
BOOTH, GARRETT & BLAIR
Established 1836
Analytical and Consulting Chemists Samplers and Weighers
228 South Ninth Street Philadelphia 7, Pa.

WARNER LABORATORIES
Cresson, Pa.
Coal Analysis—Sampling—Washability
In the Heart of Bituminous Production
Also Clay—Lime—Limestone
Mineral Fillers—Water
Established 1923 Member: A.C.I.L.

ROBERT W. HUNT COMPANY
ENGINEERS
Inspection, Tests, Consultation, Research
CHEMICAL, PHYSICAL, METALLURGICAL, CEMENT and CONCRETE LABORATORIES
175 W. Jackson Blvd., CHICAGO 4, *And All Large Cities*

HARVARD TRANSLATING & EDITORIAL SERVICE
Technical Translations
All Languages
Fast Service — High Quality Work
927 Fifteenth St., N. W. Washington 5, D. C.

Seelye Stevenson Value & Knecht
Consulting Engineers
Richard E. Dougherty, Consultant
Airports, Highways, Bridges, Dams, Water Supply, Sanitation, Tunnels, Piers, Industrial Plants, Reinforced Concrete, Steel, Industrial Waste Disposal, Foundations, Soil Studies.
CIVIL — MECHANICAL — ELECTRICAL
101 Park Avenue New York 17, N. Y.

Johnson Soils Engineering Laboratory
Laboratory and Field Testing
Shear and Consolidation Tests
Design and Construction Control
MOBILE LABORATORIES
193 West Shore Avenue
Bogota, New Jersey

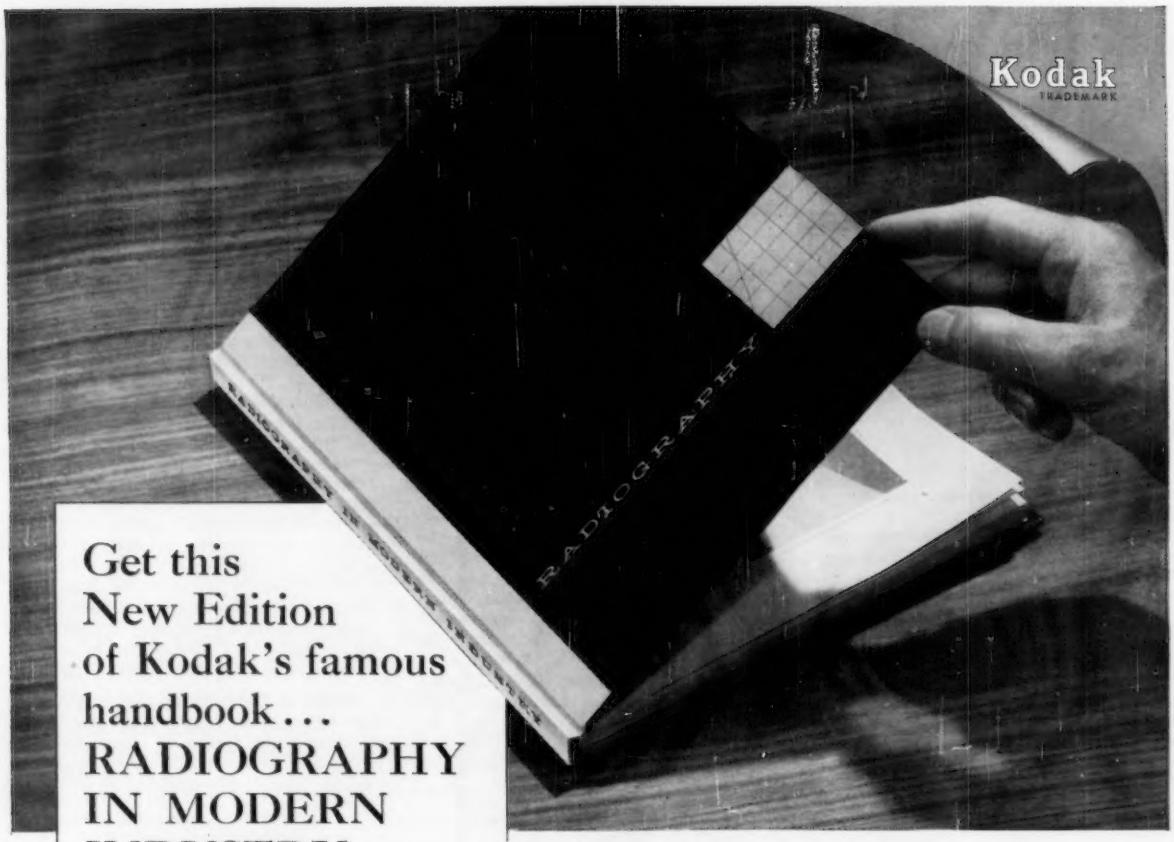
PITTSBURGH TESTING LABORATORY
Testing—Inspection—Analysis
Radiography—Soils Mechanics
Main Office Pittsburgh, Pa.
32 Laboratories in Principal Cities

NATIONWIDE LABORATORY and FIELD INSPECTION
MAGNAFLUX COMMERCIAL INSPECTION SERVICE
Magnetic particle—fluorescent penetrant—ultrasonic—electronic . . . Nondestructive testing methods for metals, carbides, ceramics, plastics, etc. Production, maintenance and erection inspections—anywhere in U. S. A. • Mineola, N. Y. • Newark, N. J. • Hartford • Bridgeport • Philadelphia • Pittsburgh • Cleveland • Cincinnati • Detroit • Indianapolis • Chicago • Tulsa • Dallas • Houston • Los Angeles • Oakland
MAGNAFLUX CORPORATION
7300 W. Lawrence Ave. • Chicago 31, Ill.

CYRUS WM. RICE & COMPANY
. . . ESTABLISHED 1916 . . .
15 NOBLE AVENUE, PITTSBURGH 5, PA.
INDUSTRIAL WATER CONSULTANTS

W. B. COLEMAN & CO.
Metallurgists-Chemists-Engineers
Spectrographic Analysis
Chemical and Physical Testing
Metallurgical Investigations
Boiler Water Conditioning
Consultation Service
9th & Rising Sun Ave., Philadelphia 40, Pa.
Member: American Council of Independent Laboratories

Oklahoma's Oldest Independent Testing Laboratory
Professional Engineers & Chemists
OKLAHOMA TESTING LABORATORIES
310 N. Klein P.O. Box 3838 Oklahoma City
Member American Council of Independent Laboratories



Get this New Edition of Kodak's famous handbook... RADIOGRAPHY IN MODERN INDUSTRY

An authoritative, up-to-the-minute text which explains the fundamentals of x-rays and gamma rays, and their use in radiography for industry.

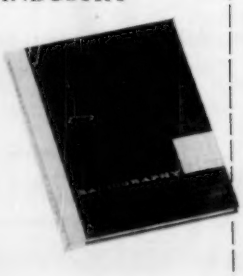
Everyone interested in industrial radiography should have the latest edition of this famous handbook. It contains all the information found in the previous text, plus up-to-the-minute additions. It tells about new technics, new sources of radiation, and new fast films; explains proper methods of using them.

No one engaged in radiography should be without this latest edition of *Radiography in Modern Industry*. Get it from your Kodak x-ray dealer, or send coupon below.

EASTMAN KODAK COMPANY • *X-ray Division* • Rochester 4, N. Y.

RADIOGRAPHY IN MODERN INDUSTRY

- size 8½ x 11 inches
- hard cover, case-bound
- 140 pages of information
- 15 chapters
- 101 text illustrations
- 19 tables
- appendix
- bibliography
- cross index
- Price, $5.00



EASTMAN KODAK COMPANY
X-ray Division, Rochester 4, N. Y.

Gentlemen: Enclosed is $5.00. Please send me "Radiography in Modern Industry." 43-2

Name _____

Address _____

City _____

State _____

PERSONALS...

News items concerning the activities of our members will be welcomed for inclusion in this column

Wallace R. Brode, associate director of the National Bureau of Standards, Washington, D. C., has been elected American Chemical Society regional director from the fourth district. Active in many professional and technical organizations Dr. Brode is 1958 president of the American Association for the Advancement of Science.

Stephen W. Benedict has been elected president of the Master Builders, Inc., a division of the American Marietta Co., Cleveland, Ohio. He also has been named vice-chairman of the board of directors of Master Builders Co., Ltd., of Canada.

Harold C. R. Carlson, president and chief consulting engineer of The Carlson Co., and president of the Carlco Corp., New York City, has been elected a Fellow of The American Society of Mechanical Engineers. He has made valuable contributions to the advancement of engineering in machine design, the spring-manufacturing industry, and as a consulting engineer. In ASTM Mr. Carlson has been active in technical and district work. He is a past-officer of the New York District Council.

Ray B. Crepps who recently retired as director of testing division, Owens-Corning Fiberglas, Research Labs., Newark, Ohio, has accepted an appointment as professor in the Structural Engineering Dept., School of Civil Engineering, Purdue University, West Lafayette, Ind. He also has set up a consulting practice in the field of materials, including reinforced plastics, for use in building constructions. A longtime, very active member of the Society, Mr. Crepps plans to continue his interest in a number of the technical committees. Currently he heads Subcommittee XVIII on Reinforced Plastics of Committee D-20 on Plastics, the Editorial Subcommittee of Committee C-20 on Acoustical Materials, and Subcommittee VIII on Windows of Committee E-6 on Methods of Testing Building Constructions.

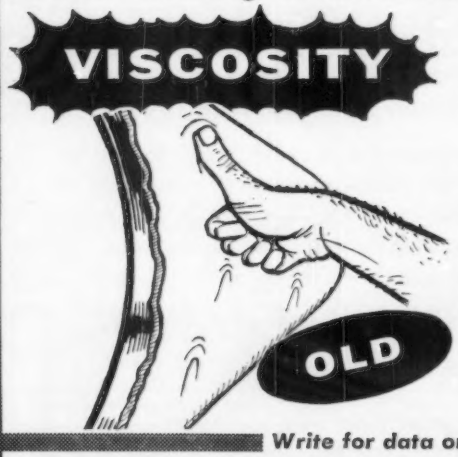
Dominador De Jesus, formerly with the Materials Testing and Physical Research Div., Bureau of Public Highways, Manila, Philippines, is now associated with C & C Construction Supply, in the same city.

Harold F. Dodge has retired as quality results engineer, Bell Telephone Laboratories, Inc., New York City. A longtime member of the Society, Mr. Dodge's valued contributions to ASTM technical work, especially his pioneering efforts on the interpretation and presentation of data, and in the preparation of the ASTM Manual on Presentation of Data (now known as the ASTM Quality Control Manual) were recognized in 1950 by an ASTM Award of Merit. Mr. Dodge has been chairman of Committee E-11 on Quality Control of Materials since its organization in 1946 and for many years prior to that time headed the subcommittee concerned with interpretation of scientific and engineering data of Committe E-1 on Methods of Testing. He also was honored by selection as the 1954 Edgar Marburg Lecturer, his subject being "Interpretation of Scientific and Engineering Data." Mr. Dodge resides at 96 Briarcliff Rd., Mountain Lakes, N. J.

Bernardo Mora Duarte, formerly visiting civil engineer, Contraloria General de la Republica de Colombia, Bogota, is now

(*Continued on page 78*)

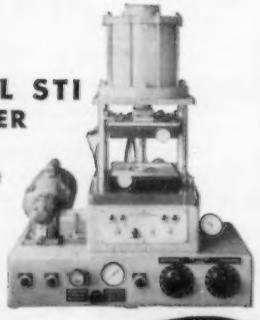
Your Testing is MODERN when your Tester is a SCOTT!



SCOTT TESTER MODEL STI
MOONEY VISCOMETER

For Viscosity, Scorch and Cure Characteristics

Over 750 Mooneys, in 57 countries, attest its world-standard position. ONLY the Scott truly conforms to the **"Mooney Point" Designations of ASTM D927 and D1077.**



NEW

Write for data on Scott Model STI and other Testers

SCOTT TESTERS*

World-standard for testing elastomers in conformity with ASTM Specifications

SCOTT TESTERS, INC. 120 Blackstone St. Providence, R. I.

*Registered Trademark

Sales Rep. for Ala., Ga., Ky., N. C., S. C., Tenn., Va.
SCOTT TESTERS (Southern), Inc.
P. O. Box 834
Spartanburg, S. C.

Sales Rep. for the British Isles.
UNIVERSAL WINDING COMPANY
(Umisel Division)
Saville St. at Oxford Rd.
Manchester, England

Representatives in Foreign Countries

FOR FURTHER INFORMATION CIRCLE 800 ON READER SERVICE CARD

ACQUISITION OF KROUSE COMPANY ADDS 65 TYPES OF FATIGUE TESTING MACHINES TO TATNALL LINE

Recently The Budd Company added to the testing equipment line produced and sold by its subsidiary, Tatnall Measuring Systems Company, through the acquisition of the Krouse Testing Equipment Company, nationally known manufacturer of fatigue testing machines.

The five Krouse machines shown on this page are representative of the 65 types of machines that Krouse manufactures, all of which have been added to the Tatnall line.

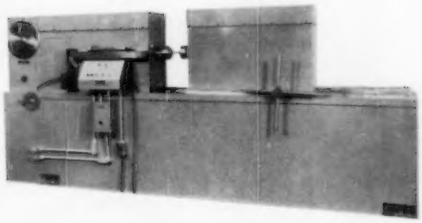
If the testing problem is known, one of these 65 types—in all probability—can solve it.

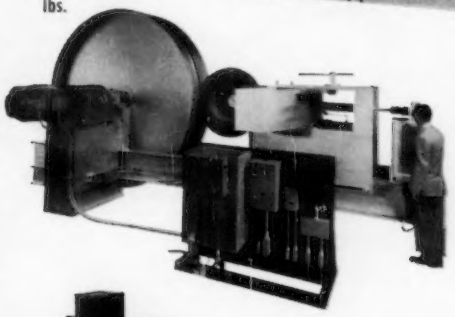
This acquisition has brought to Tatnall the manufacturing resources and the engineering skills of the Krouse Company.

HIGH SPEED DIRECT STRESS MACHINE

Using slip clutch drive and equipped with Prot program control.

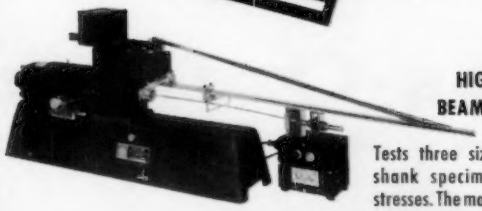
Speed—4,000 cpm
Capacity—±10,000 cyclic
Preload—±10,000 lbs.





TIRE AND WHEEL TESTING MACHINE

Surface Speed—to 60 mph
Wheel Load—to 15,000 lbs.
Axis Angle—±15°
Automatic Load Maintainer



HIGH SPEED ROTATING BEAM FATIGUE MACHINE

Tests three sizes of simple straight shank specimens under reversed stresses. The machine is shown equipped with a wire, rod and tubing testing adapter.

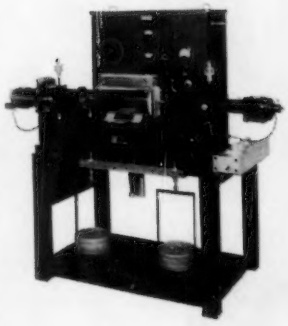
With Wire Adapter
Capacity—⅜" to 1/32" steel wire
Speed range—500 to 10,000 cpm

ROTATING BEAM MACHINE

Capacity—0—200 in. lbs.
Specimen shank sizes—¼", ⅜", ½"
Speed range—500 to 10,000 cpm

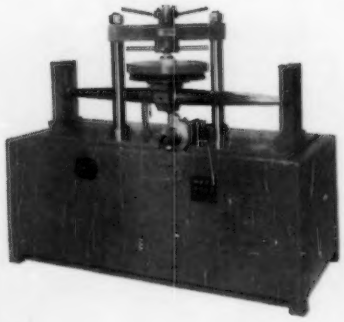
HIGH SPEED HIGH TEMPERATURE FATIGUE MACHINE

Tests a machined or cast specimen under reversed bending at controlled temperatures. The specimen is supported as a simple beam with uniform bending moment over the test section.
Capacity—850 in. lbs.
Speed Range—3000 to 12,000 cpm
Temperature—1800°F.



PRODUCTION SPRING FATIGUE TESTING MACHINE

This machine operates at high speed and tests a large number of similar springs at the same range of stresses.
Capacity—200 (¾" diameter) springs
Speed—Approximately 3000 cpm.
Amplitude—0 to 5/8"



TATNALL MEASURING SYSTEMS COMPANY

A SUBSIDIARY OF THE BUDD COMPANY • P. O. BOX 245 • PHOENIXVILLE, PENNSYLVANIA

CANADA—NON-DESTRUCTIVE TESTING CORP. • 46 HOLLINGER RD. • TORONTO 16, ONT.

Budd

FOR FURTHER INFORMATION CIRCLE 801 ON READER SERVICE CARD

Personals

(*Continued from page 76*)

chief engineer, Laboratory of Soils and Pavements, Special District of Bogota.

Gordon C. Farnsworth, chief metallurgist and laboratory engineer at General Motors Corp.'s Truck and Coach Div., Pontiac, Mich., retired after 38 years of service with the company. He had been associated with the Truck and Coach Division for the last 25 years. Mr. Farnsworth had been representing his company in ASTM and on Committee A-3 on Cast Iron since 1934.

Alfred J. Ferretti, head of the Department of Mechanical Engineering, Northeastern University, Boston, Mass., has been granted the rank of Fellow of The American Society of Mechanical Engineers. Professor Ferretti's specialty is thermodynamics and applied mechanics, and he has been consultant for projects involving design, heat, power, refrigeration, and testing of materials.

Maxwell Gensamer, professor of metallurgy at Columbia University, New York City, has been named Howe Memorial Lecturer for 1958, the lecture to be given at the annual American Institute of Mining Metallurgical and Petroleum Engineers meeting in February.

W. Paul Gerhart has retired as metallurgical engineer, Bethlehem Steel Co., Bethlehem, Pa. Affiliated with the Society since 1925, Mr. Gerhart had served through the years on Committee A-1 on Steel and several of its subcommittees. He has been especially interested in steel plate and in the materials work of the ASME Boiler Code Committee.

David M. Greer, of Greer Engineering Associates, Montclair, N. J., and G. Kenneth Jewell, consulting soils engineer and formerly soils engineer for the Ohio Turnpike Commission, have formed a partnership for the practice of soils and foundation engineering, under the name Greer-Jewell & Associates. The new firm's office and laboratory are at 195 Chittenden Ave., Columbus, Ohio.

W. A. Gruse recently retired from Gulf Oil Corp. He had been associated with the Gulf Fellowship at Mellon Institute since 1919. During this period the Fellowship expanded into a number of fields, including investigations into the origin of petroleum, basic research in catalysis, crude oil correlation, and other important phases of petroleum research. Mr. Gruse has been active for many years in Committee D-2 on Petroleum.

Leroy V. Gullings, former technical service director for American Rock Wool Corp., Birmingham, Ala., is now assistant plant manager.

Onslow B. Hagar, director of research at Alco Oil and Chemical Corp., Philadelphia, has been elected vice-president of the company.

W. L. Healy, specialist, Switchgear and Control Div., General Electric Co., Philadelphia, Pa., was selected by the Standards Engineers Society to receive a Fellowship award. He served as president of the society 1953–1954.

B. J. Higgins, formerly with Sylvania-Corning Nuclear Corp., Hicksville, L. I., N. Y., is now plant manager, Small Tube Products, Inc., Altoona, Pa.

Henry J. Jacobson, formerly quality control manager for P. R. Mallory Co., Indianapolis, Ind., has resigned to form the firm of Sutherland, Jacobson and Associates, Quality Control Consultants, at 4222 Broadway, Indianapolis, Ind. His partner is Marjorie L. Sutherland.

D. Hugh Jenks, manager, Asphalt Dept., Ashland Oil and Refining Co., Ashland, Ky., has been elected chairman of the board of The Asphalt Inst.

Jerome J. Kanter, director of engineering research and development, Crane Co., Chicago, Ill., has been transferred to the rank of Fellow of The American Society of Mechanical Engineers. Mr. Kanter directed investigations which led to the development of chromium-molybdenum alloy steel compositions. An early investigator in the high-temperature field, he is the holder of many patents. A longtime member of ASTM, Mr. Kanter has been very active in the metals committees, receiving an ASTM Award of Merit in 1952, in recognition of valued contributions. Currently he serves as vice-chairman of the Joint ASTM-ASME Committee on the Effect of Temperature on the Properties of Metals, also as a vice-chairman of Committee A-1 on Steel. He is a past officer of the ASTM Chicago District.

Stephen J. Kennedy, research director, Textile, Clothing and Footwear Div., Quartermaster Research and Development Center, Natick, Mass., will receive the Harold De Witt Smith Memorial Medal of ASTM Committee D-13 on Textile Materials, in recognition of outstanding achievement in research on fibers and their utilization. Presentation will be made on Thursday, March 20, 1958, during the Spring Meeting of Committee D-13, March 18–21, at the Sheraton-Park Hotel, Washington, D. C.

S. C. Killian, assistant general manager, Delta-Star Electric Div., H. K. Porter Co., Inc., Chicago, Ill., has been named a vice-president of the Division.

R. T. Kirkpatrick has accepted a position as research chemical engineer, Monsanto Chemical Co., Inorganic Chemicals Div., Research Dept., St. Louis, Mo. Formerly he was associated with Shell Chemical Corp., Ventura, Calif.

(*Continued on page 80*)

Atlas-Ometers

...Used all over the world

Give quick accurate answers to the deteriorating effect of sunlight, weathering, washing and wearing of materials. A few minutes, hours, or days in Atlas-Ometers equals years of normal use deterioration.

Indispensable for speed testing in product development and quality control in production. Exact standardized test programs can be repeated as frequently as required.

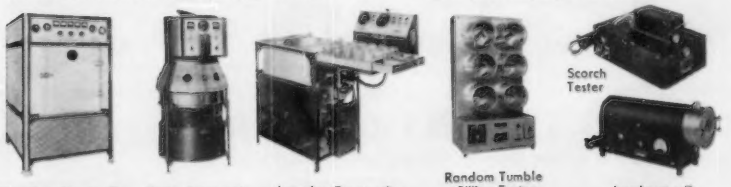
Used extensively in these industries:

Clothing makers
Printing ink manufacturing
Plastic and coated fabrics
Electric manufacturing
Dyestuffs and chemicals
U.S. Government
Rubber products
Automotive industry
Consulting laboratories
Woolens and worsteds
Rugs and carpets
Soaps and detergents
Paint, varnish, dry colors and many others

Complete manual on each machine on request

Atlas Electric Devices Company
4114 N. Ravenswood Ave., Chicago 13, Ill., U.S.A.

Weather testing translucent fiberglas for outdoor use in an Atlas Weather-Ometer at the Alsynite Company of America.



Weather-Ometer® Fade-Ometer® Launder-Ometer® Random Tumble Pilling Tester Accelerotor®

FOR FURTHER INFORMATION CIRCLE 802 ON READER SERVICE CARD

Supplying the Nation's Laboratories from Coast to Coast

HARSHAW SCIENTIFIC Spotlights pH Meters

Including two *NEW* Beckman meters. The "Zeromatic" line operated "push button" pH meter and the "Pocket" pH meter.

The Zeromatic provides Easier, Faster, Routine pH measurements; greater versatility, accuracy, reproducibility. The pocket model which is only 6″ x 3″ x 2″ and utilizes a combination glass and reference electrode offers the maximum in portability and convenience.

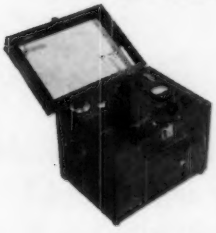
Space permits only a brief description. We welcome your requests for more detailed information.

H-29604

H-29604—Beckman Pocket pH meter, battery operated 6″ x 3″ x 2″ deep. Light weight with unique combination glass and reference electrode which permits holding meter in one hand while taking readings, leaving the other hand free for recording **$99.50**

H-28915

H-28915—Beckman Zeromatic pH meter, line operated. Simply push button and take pH or millivolt reading. Drift free, no warm-up time, line voltage compensation, continuous 0-14 pH scale. Outlets provided for recorder, polarizing current, etc. **$295.00**



H-28901

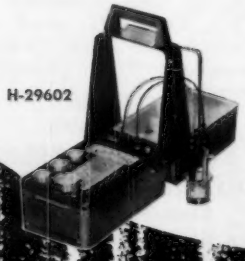
H-29601—Beckman Model N-1 pH meter, battery operated. Range 0-14 pH. Temperature compensator covers 0-100°C. Rapid measurements to 0.1 pH and with careful technique to 0.03 pH **$310.00**

H-28901—Beckman Model GS pH meter, battery operated. For special pH problems and applications requiring extreme precision. This ultra-sensitive instrument is accurate to 0.0025 pH. The meter is a modified model G, which provides 20 times the sensitivity of standard null-meter measuring circuits. Utilizes same electrodes as model G . . **$625.00**

H-29601

H-28900—Beckman Model G pH meter, battery operated. Designed for highest precision and versatility in pH studies, oxidation-reduction potential measurements and titrations with accuracy and reproducibility to ±0.02 pH. **$475.00**

H-28900



H-29602

H-29602—Beckman Model N-2 pH. meter. A compact, battery operated meter in carrying case designed especially for portability. Ideal for field use. Range 0-14 pH. Case has compartment for electrodes, beaker and solutions . . . **$360.00**

Service facilities and complete electrode stocks are maintained at all Harshaw Scientific Branches

HARSHAW SCIENTIFIC

Division of the Harshaw Chemical Co. • Cleveland 6, Ohio

Sales Branches and Warehouses

Cleveland 6, Ohio, 1945 East 97th St. — **Houston 11, Texas,** 6622 Supply Row
Cincinnati 13, Ohio, 6265 Wiehe Road — **Los Angeles 22, Calif.,** 3237 S. Garfield Ave.
Detroit 28, Mich., 9240 Hubbell Ave. — **Philadelphia 48, Pa.,** Jackson & Swanson Sts.
Sales Offices: Baton Rouge, La. • Buffalo 2, N.Y. • Pittsburgh 22, Pa. • Oakland 11, Calif.

FOR FURTHER INFORMATION CIRCLE 803 ON READER SERVICE CARD

Personals

(*Continued from page 78*)

Jules Labarthe has been appointed professor of textile technology, Carnegie Institute of Technology, Pittsburgh, Pa. Professor Labarthe will play a major role in developing a new program in textile technology in the Department of Home Economics of Margaret Morrison Carnegie College, designed to prepare young women for positions in business and industry. For the past 27 years, Dr. Labarthe has been senior fellow on the Commodity Standards Fellowship maintained at Mellon Institute by the Kaufmann Department Stores of Pittsburgh. A longtime ASTM member, he currently is serving on the Administrative Committee on End-Use Products; also is active in the work of technical committees concerned with textiles and wax polishes and related material.

William L. Lamar has been promoted to area chief, quality of water branch, Pacific Coast Area, U. S. Geological Survey, Menlo Park, Calif.

Carl L. Liebau, formerly president, is now chairman, Federal Malleable Co., West Allis, Wis.

G. L. McMillin has been named president and general manager of Canadian Steel Foundries (1956) Ltd. He formerly was vice-president and general manager.

Arthur H. Nellen is a newly elected member of the Board of Directors, Lee Rubber and Tire Corp., Conshohocken, Pa., filling a vacancy caused by the death of George S. Mahanna. Mr. Nellen is vice-president in charge of development and research.

C. A. Neusbaum has retired as laboratory director, Standard Inspection Lab., Esso Research and Engineering Co., Linden, N. J. Dr. Neusbaum has represented Esso in the Society and has been very active in Committee D-2 on Petroleum Products and Lubricants for a number of years, serving as chairman of the research divisions concerned with measurement and sampling, and analysis of fuels. He is continuing his interest in ASTM through an individual membership. Dr. Neusbaum is opening offices as a consultant.

Howard F. Peckworth, managing director of the American Concrete Pipe Assn., Chicago, Ill., has been appointed by Governor Stratton to a four-year term as a member of the Northern Illinois Local Governmental Area Planning Commission. The personal honor to Mr. Peckworth is also an honor to the profession, as it signifies the public's growing awareness of the importance of the engineer.

Charles E. Peterson, until recently chief metallurgist, Mackintosh-Hemphill Div., E. W. Bliss Co., has been named manager of manufacturing operations for the division's Pittsburgh and Midland, Pa., plants.

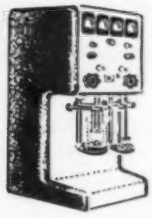
C. D. Ramsden, formerly vice-president and general manager, has been named president and general manager, Pacific Coast Engineer Co., Alameda, Calif.

Thomas G. Reynolds announces the formation of Reynolds-Bohna & Co., Inc., consulting and design engineers, with offices at 1617 Pennsylvania Boulevard, Philadelphia, Pa. Mr. Reynolds has been executive engineer for the Catalytic Construction Company in that city.

Edward P. Sandbach, formerly coordinating metallurgist, United Engineering and Foundry Co., is now chief metallurgist, Mackintosh-Hemphill Div., E. W. Bliss Co., heading the metallurgical departments in the division's Pittsburgh and Midland, Pa., plants.

William D. Simpson retired as chief engineer, Seaboard Air Line Railroad Co., Norfolk, Va., after 42 years' service with the Railroad's engineering department.

(*Continued on page 82*)



Eberbach

electro-analysis apparatus

Rugged for continuous duty—yet versatile for research. Built-in rectifier delivers 8 volts, 5 amperes DC to each spindle or 10 amperes DC to one. Ammeter, voltmeter, polarity reversing switch and power control knob are provided for each position. Case is stainless steel and cast aluminum. Operates from 115 or 230 volt, 60 cycle AC. Unit measures 14½" by 16½" by 29½" high. Ask for illustrated bulletin 130F.

Eberbach CORPORATION
SCIENTIFIC INSTRUMENTS & APPARATUS
ANN ARBOR, MICH.

CIRCLE 804 ON READER SERVICE CARD

Standardize on Easy-to-Read Flat Bore

YEL ⊖ BAK

Reg. U. S. Pat. Office

ENGRAVED STEM THERMOMETERS

For all Laboratory and Industrial Purposes

ASICO instruments are accurate and dependable, guaranteed to meet all ASTM and N.B.S. specifications.

Combining the greater contrast of the YEL O BAK and wide flat mercury column ASICO thermometers decrease the possibility of reading errors.

Also Available

MIDGET INDUSTRIAL THERMOMETERS

SENIOR MIDGET INDUSTRIAL THERMOMETERS
(Separable Socket)

A.P.I. HYDROMETERS

MERCURY IN GLASS THERMOSTATS

ASICO
Reg. U. S. Pat. Off.

Write for Catalog 25-A

ACCURACY SCIENTIFIC INSTRUMENT CO.

2903 N. 12th Street Philadelphia 33, Pa.

CIRCLE 805 ON READER SERVICE CARD

Nuclear-Chicago offers complete new nucleonic laboratory instrumentation

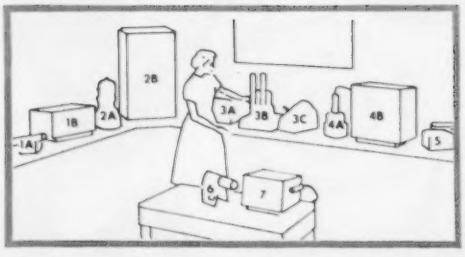
More than two years' research went into the 33 *all new* instruments that have been added to the Nuclear-Chicago line now offered to the small or large nucleonic research laboratory. Among these high-quality advance-design instruments are many completely automatic counting systems.

Whether you are just starting a modest radioisotope laboratory or expanding present facilities, call on Nuclear-Chicago. For complete details on the new Nuclear-Chicago line, write for our new Catalog "Q".

1A Model DS5-3P Scintillation Detector with exposed 2" x 2" sodium iodide crystal and **1B** Model 132 Analyzer Computer for precision gamma-ray measurements using pulse-height discrimination techniques.

2A Model DS5-5 Scintillation Well Counter with exclusive "scaler-spectrometer" circuit and **2B** Model 1820 Recording Spectrometer for automatic quantitative energy separation of gamma-ray spectra.

3A Model 183B Count-O-Matic Binary Scaler, **3B** Model C110B Automatic Sample Changer with Model D47 Gas Flow Counter, and **3C** Model C111B Printing Timer for completely automatic changing, counting, and recording of as many as 35 soft beta emitting radioactive samples.



4A Model 3054 Manual Sample Changer with Model DS5 Scintillation Detector which features interchangeable alpha, beta, or gamma sensitive crystals connected to Nuclear-Chicago's finest scaler, the **4B** Model 192A Ultrascaler. Model 192A features decade scale of 10,000, one millivolt sensitivity, and precision automatic circuitry.

5 Model 2612P Portable Survey Meter contains a 1.4 mg/cm² thin window G-M tube for surveying for alpha, beta, or gamma contamination up to 20 milliroentgens per hour.

6 Model 2586 "Cutie Pie" features interchangeable ionization chambers for measuring beta, gamma, or x-radiation up to 250 roentgens per hour.

7 Model 1620A-S Analytical Count Rate Meter offers a wide choice of full scale ranges, four time constants, wide range high voltage supply. It is shown with a Model D34 thin window G-M tube and P11 probe for continuous monitoring or analytical radioactivity determinations.

nuclear-chicago
CORPORATION

259 WEST ERIE STREET • CHICAGO 10, ILLINOIS

FOR FURTHER INFORMATION CIRCLE 806 ON READER SERVICE CARD

Personals

(*Continued from page 80*)

Bruce R. Silver has retired as technical assistant to vice-president, The New Jersey Zinc Co., New York City. Mr. Silver, who is continuing his membership through 1958, resides at 303 East 37th St., New York City.

John C. Sprague, director, Division Materials Testing Lab., Corps of Engineers, U. S. Department of the Army, Marietta, Ga., is being assigned to a new tour of duty in Iran. He will serve as chief, Foundation and Materials Branch, his present address being U. S. Army Engineering District, Gulf, Corps of Engineers, APO 205, New York City. He had been serving on Committees C-9 on Concrete and Concrete Aggregates, and D-4 on Road and Paving Materials, and had been elected as a member of the new ASTM Southeastern District Council. Mr. Sprague will be located in Teheran for approximately the next two years.

Robert L. Storey, recently retired from the U. S. Army, is now chief, Metering Stations at Bateman and Chippewa Falls; and supervisor, Wisconsin and Duluth, Minn., Great Lakes Pipe Line Co., Chippewa Falls, Wis.

George Tennent has retired as chief chemist, Hummell-Ross Fibre Div., Continental Can Co., Hopewell, Va.

Emery I. Valko has been appointed an associate professor in the Division of Chemistry, Lowell Technological Inst., Lowell, Mass. Dr. Valko is vice-president in charge of research and development at Onyx Oil and Chemical Co., Jersey City, N. J.

T. E. Veltfort, managing director, Copper and Brass Research Assn., New York City, has been elected chairman of the Standards Council of the American Standards Assn.

L. L. Whiteneck, vice-president and director of corrosion control and material research, Plicoflex, Inc., Los Angeles, is 1958–1959 president of the National Association of Corrosion Engineers. Mr. Whiteneck is active in ASTM Committee D-1 on Paint, Varnish, Lacquer, and Related Products. He also serves on ASTM Southern California District Council.

Kenneth W. Wright has retired as superintendent, Ash Grove Lime and Portland Cement Co., Chanute, Kans.

Franz P. Zimmerli retired as director of research, Associated Spring Corp., Bristol, Conn., after 30 years of service with the company. The company announcement of Mr. Zimmerli's retirement noted appreciation for his many technical contributions to the art of spring-making and the science of metallurgy, "responsible to a very large extent for the Corporation's growth to its present pre-eminent position" as a manufacturer of precision mechanical springs. A longtime member of the Society and a former Director, and Detroit District Councilor, Mr. Zimmerli plans to continue his ASTM affiliation, and to maintain interest in Committee A-1 on Steel and its Subcommittee IV on Spring Steel and Steel Springs. He resides at 43 Butternut St., Lyons, N. Y. Mr. Zimmerli's engineering achievements were recognized by the American Society for Metals in 1947 when he received the Albert Sauveur Award for his work in demonstrating that favorable stresses could be imparted to the surface layers of metal parts by shot-peening. He was the ASM William P. Woodside Lecturer in 1951.

THWING-ALBERT TREASURE CHEST

The most unique and complete instrument checking set.

Combining into one portable instrument a highly accurate potentiometer and a complete instrument checking and calibrating set.

Checks all kinds of potentiometers, pyrometers, thermocouples, recorders, controllers, sensing elements, pressure pick-ups, load cells, stain gages, etc.

Ideal for measuring temperatures or any other millivoltage output.

Ranges of zero to 101 millivolts and zero to 1 volt.

Permits checking while instruments are in service.

The Treasure Chest is self-checking.

Meets every requirement for accuracy, utility and ruggedness.

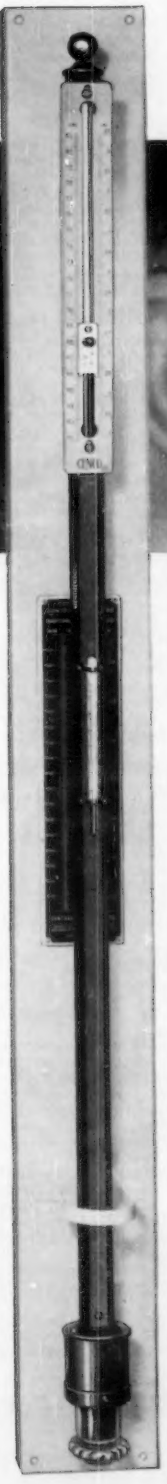
THWING-ALBERT INSTRUMENT COMPANY

5339 Pulaski Avenue **Philadelphia 44, U.S.A.**

#141

FOR FURTHER INFORMATION CIRCLE 807 ON READER SERVICE CARD

High visibility...



Lifetime accuracy...

CENCO®
Mercury Barometer

Here's a practical mercury barometer that's easy to read . . . accurate . . . capable of fine adjustment . . . and built for years of dependable service. The glass tube is completely enclosed in a hexagonal brass tube with metric and English scales attached. Constructed as prescribed by the U.S. Weather Bureau to conform to correction charts established by them. This is an unusually fine instrument at a remarkably low price.

Order today for prompt delivery

No. 76890 Cenco Mercury Barometer for altitudes 0 to 4000 ft..... each, **$58.00**

No. 76891 Cenco Mercury Barometer for altitudes from 1500 to 10,000 feet.....each, **$65.00**

No. 76892 Metal Barometer Mounting with conversion table..... each, **$7.50**

cenco
The most complete line of scientific instruments and laboratory supplies in the world

CENTRAL SCIENTIFIC COMPANY

General Offices and Factory—1718-G Irving Park Road • Chicago 13, Illinois

Branches and Warehouses—Mountainside, N. J. • Boston • Birmingham
Central Scientific Co. of California—Santa Clara • Los Angeles
Refinery Supply Company—Tulsa • Houston
Central Scientific Co. of Canada, Ltd.—Toronto • Montreal • Vancouver • Ottawa

FOR FURTHER INFORMATION CIRCLE 808 ON READER SERVICE CARD

NEW MEMBERS.....

The following 102 members were elected from December 23, 1957 to January 15, 1958 making the total membership 9155... Welcome to ASTM

Note—Names are arranged alphabetically—Company members first then individuals—Your ASTM Year Book shows the areas covered by the respective Districts

CHICAGO DISTRICT (5)

National-Standard Co., R. E. Koontz, electrical engineer—copperply wire sales, 8th & Howard Sts., Niles, Mich.

Peabody-Southern Coal Co., James R. Jones, combustion engineer, Prudential Plaza, 26th floor, Chicago 1, Ill.

Tee-Pak, Inc., E. C. Filter, technical superintendent, 3520 S. Morgan St., Chicago 9, Ill.

Bronson, Paul, president, Best Block Co., 3522 N. Fratney, Milwaukee 12, Wis.

Frandsen, Warren E., sales manager, Voss Belting and Specialty Co., 5645 N. Ravenswood Ave., Chicago 26, Ill.

Leadabrand, Joseph A., manager—Soil-Cement Bureau, Portland Cement Assn., 33 W. Grand Ave., Chicago 10, Ill.

Levin, George L., owner, George Lloyd Levin, Engineers, 2395 University Ave., St. Paul 14, Minn.

Miceli, A. S., development manager, U. S. Rubber Co., 4300 New Haven Ave., Fort Wayne 4, Ind.

Price, Walter M., superintendent, Technical Service Lab., Cities Service Oil Co., Box 718, East Chicago, Ind.

Riordan, George L., owner, Pilot Engineering Service, 1721 E. Lake Bluff Blvd., Milwaukee 11, Wis.

Scheid, Carl C., engineer, General Electric Co., X-Ray Dept., 4855 Electric Ave., Milwaukee 1, Wis. [A]*

Ueber, John D., director of special projects, American Rock Wool Corp., Technical Service Div., Wabash, Ind. [A]

CLEVELAND DISTRICT (4)

Youngstown Steel Tank Co., R. M. Bentley, chief engineer, 512 Elk St., Youngstown 1, Ohio.

Buckley, Robert A., technical service director, Ferro Chemical Corp., 450 Krick Rd., Bedford, Ohio [A]

Polley, E. W., chief chemist, The Youngstown Sheet & Tube Co., Youngstown 1, Ohio.

DETROIT DISTRICT (6)

Doyen, Patrick S., sales manager, Welding Equipment and Supply Co., 5225 E. Davison Ave., Detroit 12, Mich.

Farmer, J. I., assistant to president, Greenback Industries, Inc., 2527 W. Maple Rd., Birmingham, Mich.

Hamme, Richard N., proprietor Geiger & Hamme, Box 512, Ann Arbor, Mich.

Kropf, Richard B., metallurgist, The International Nickel Co., Inc., 67 Wall St., New York, N. Y. For mail: 19842 James Couzens Hwy., Detroit 35, Mich.

Maki, Raymond M., formulator, Rinshed-Mason Co., 5935 Milford, Detroit 10, Mich.

Nensewitz, Karl, manager, Materials and Methods Dept., Besser School Director, Besser Co., Alpena, Mich.

NEW ENGLAND DISTRICT (13)

Barre Granite Assn., Inc., Barre, Vt.

Maguire and Associates, Charles A., Frederick H. Paulson, partner, 1100 Turks Head Bldg., Providence 3, R. I.

Sylvania Electric Products, Inc., Lighting Div., Wilfrid G. Matheson, engineering supervisor, 60 Boston St., Salem, Mass.

Thomson Manufacturing Co., Judson L., D. I. Zenobia, chief engineer, Electrical Contacts Div., 5 Sawyer Rd., Waltham 54, Mass.

Brask, Henry, president, Brask Engineering Co., 177 State St., Boston 9, Mass.

Collins, Paul J., cadet hydraulic engineer, Stone & Webster, Inc., 49 Federal St., Boston, Mass. For mail: 395 Marlborough St., Boston 15, Mass. [A]

Einfurer, Donald C., section chief, engineering services, Titeflex, Inc., Hendee St., Springfield 4, Mass.

Loughridge, Frederick A., engineering specialist—glass, Sylvania Electric Products, Inc., 60 Boston St., Salem, Mass.

Maloof, Samuel R., staff member, Nuclear Metals, Inc., 155 Massachusetts Ave., Cambrdige, Mass. For mail: 269 Lexington St., Watertown 72, Mass.

Perednia, Daniel A., manufacturing engineer, Gabriel Electronics Div., The Gabriel Co., 135 Crescent Rd., Needham Heights 94, Mass.

Supnik, Ross H., treasurer, Plas-Tech Equipment Corp., 751 Main St., Waltham 54, Mass.

Thibeau, Charles E., chief inspector, Insulating Fabricators of New England, Inc., 69 Grove St., Watertown, Mass. For mail: Groton, Mass.

NEW YORK DISTRICT (1)

Brabender Instruments, Inc., C. W., C. W. Brabender, president, 50 E. Wesley St., South Hackensack, N. J.

Long Island Materials Testing Laboratory, Inc., Horace A. McAllister, president, Box 288, Farmingdale, N. Y.

National Association of Glue Manufacturers, Inc., Clyde D. Marlatt, secretary and treasurer, 55 W. 42nd St., New York 36, N. Y.

Paper Shipping Sack Manufacturers' Assn., Inc., Frank Pocta, executive secretary and chairman, technical committee, 370 Lexington Ave., New York 17, N. Y.

Spargo Wire Co., Inc., James A. Spargo, III, sales manager, Rome, N. Y.

United States Rubber Co., Research Center, Robert H. Griffith, supervisor, physical testing labs., Wayne, N. J. [S]**

Bachrach, Max, mammalian fiber consultant, 370 Seventh Ave., New York 1, N. Y.

Bohacz, Walter, assistant utilization engineer, American Gas Assn., Inc., 420 Lexington Ave., New York 17, N. Y.

Chamberlin, Noel S., chemical engineer, Havens & Emerson, 233 Broadway, New York 7, N. Y. For mail: 9 Sherman Ave., Pompton Plains, N. J.

Day, Lester E., materials engineer, Picatinny Arsenal, Dover, N. J.

McCosh, W. C., sales manager, spectroscopic, National Carbon Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York, N. Y.

McNeil, Thomas J., eastern representative, Soiltest, Inc., 4711 W. North Ave., Chicago 39, Ill. For mail: Suite 838, 60 E. 42nd St., New York 17, N. Y.

Werner, William B., test engineering div., Hazeltine Corp., 58-25 Little Neck Pkwy., Little Neck, L. I. 62, N. Y.

NORTHERN CALIFORNIA DISTRICT (8)

Moriarty, John T., technical representative, Quaker Pioneer Rubber Div., H. K. Porter Co. (Delaware), Box 791, Pittsburg, Calif.

* [A] denotes Associate member.
** [S] denotes Sustaining member.

(Continued on page 86)

MANUFACTURED BY MAKERS OF WILSON "ROCKWELL"—
"THE WORLD'S STANDARD OF HARDNESS TESTING ACCURACY"
WILSON "TUKON"
MICRO-HARDNESS TESTERS

Here's the accurate way to test such fine precision parts as—

fine wire • very thin metal • shallow superficially-hardened surfaces • small components • surface coatings • jewels plastics • glass • and many other materials

Use both Knoop and 136° Diamond Pyramid Indentors

Wilson engineers help you choose model to fit your requirements

ACCO **WILSON**
MECHANICAL INSTRUMENT DIVISION
AMERICAN CHAIN & CABLE
230-C Park Avenue, New York 17, N.Y.

Write for Booklet DH-328 for complete information on WILSON "TUKON" Micro and Macro Hardness Testers.

FOR FURTHER INFORMATION CIRCLE 809 ON READER SERVICE CARD

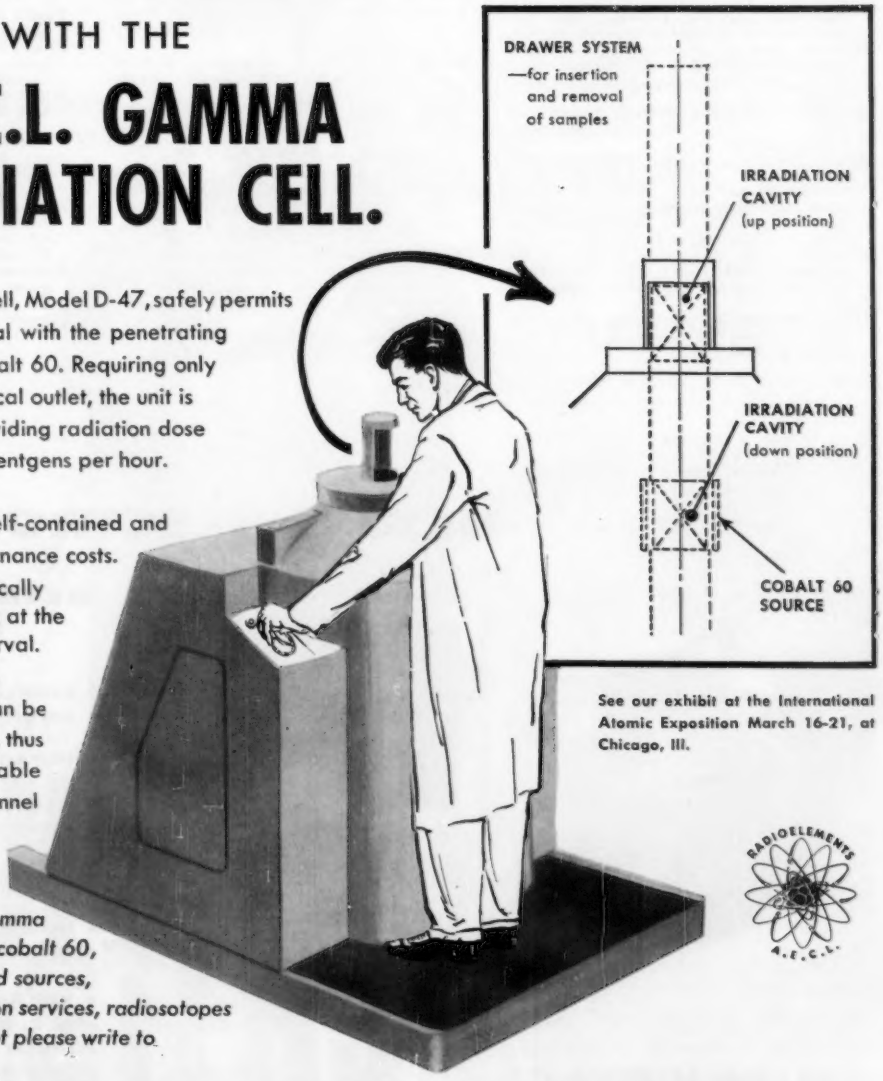
NOW - STUDY THE EFFECTS OF GAMMA IRRADIATION IN YOUR OWN LABORATORY

WITH THE

A.E.C.L. GAMMA IRRADIATION CELL.

The Gamma Irradiation Cell, Model D-47, safely permits the irradiation of material with the penetrating gamma radiation of Cobalt 60. Requiring only a connection to an electrical outlet, the unit is ready to go to work providing radiation dose rates up to 1,000,000 roentgens per hour.

The D-47 is completely self-contained and is virtually free of maintenance costs. A timing device automatically terminates the irradiation at the end of a preset time interval. With minimum instruction, a series of irradiations can be handled by a Technician, thus conserving the more valuable time of supervising personnel



See our exhibit at the International Atomic Exposition March 16-21, at Chicago, Ill.

For information on the Gamma Irradiation Cell, kilocurie cobalt 60, radiography machines and sources, neutron sources, irradiation services, radiosotopes and teletherapy equipment please write to

ATOMIC ENERGY OF CANADA LIMITED

COMMERCIAL PRODUCTS DIVISION

P.O. Box 93 Ottawa, Canada

57-1

FOR FURTHER INFORMATION CIRCLE 810 ON READER SERVICE CARD

New Members

(*Continued from page 84*)

OHIO VALLEY DISTRICT (15)

Philway Manufacturing Co., C. P. Galloway, president, Box 470, Ashland, Ohio.

Poole, George M., chief metallurgist, Ingersoll Steel Div., Borg-Warner Corp., New Castle, Ind.

PHILADELPHIA DISTRICT (2)

Whitaker, Fred, Co., Curtis C. Allen, assistant superintendent, Ridge Ave. & Scotts Lane, Philadelphia 29, Pa.

Brenner, Clifford S., textile chemist, Glasgo Limited, Inc., Penn and Line Sts., Lansdale, Pa. For mail: 304 Newington Dr., Hatboro, Pa.

Camen, Richard S., textile engineer, Engineering Dept., Glasgo Limited, Inc., Penn and Line Sts., Lansdale, Pa. For mail: 4658 H St., Philadelphia 24, Pa. [A]

Harroun, Dale T., professor and consulting engineer, University of Pennsylvania, Room 222, Engineering Bldg., Philadelphia 4, Pa.

Industrial Test Lab., Technical Supervisors Assn., U. S. Naval Shipyard, Bldg. 121, Philadelphia 12, Pa.

Millar, Donald J., engineer, Alexander Construction Co., Inc., 714 Edgmont Ave., Chester, Pa. [A]

Milman, Alan M., research and development, Textured Yarn Co., Inc., 4041 Ridge Ave., Bldg. 31, Philadelphia 29, Pa.

Oberdorf, C. H., manager, research and development, Frederick H. Levey Co., Inc., 1223 Washington Ave., Philadelphia 47, Pa.

Oliver, William H., purchasing agent, The Pusey & Jones Corp., Foot of Poplar St., Wilmington 99, Del.

Reynolds, Thomas G., president, Reynolds-Bohna and Co., Inc., 1617 Pennsylvania Blvd., Philadelphia 3, Pa.

Roll, Frederic, associate professor, University of Pennsylvania, School of Civil Engineering, Philadelphia 4, Pa.

Rosenfeld, Maurice S., supervisor, airframe branch, Aero. Structures Lab., Naval Air Material Center, Philadelphia Navy Base, Philadelphia 12, Pa. For mail: 8133 Williams Ave., Philadelphia 50, Pa.

Teiser, Stanley A., cellulose products superintendent, E. I. du Pont de Nemours and Co., Inc., Sales Development Lab., Box 152, Penns Grove, N. J.

PITTSBURGH DISTRICT (3)

Guild, Lloyd V., vice-president, Burrell Corp., 2223 Fifth Ave., Pittsburgh 19, Pa.

Langer, Bernard F., consulting engineer, Westinghouse Electric Corp., Bettis Atomic Power Div., Box 1468, Pittsburgh 30, Pa.

Rowley, R. Dean, manager, materials manufacturing dept., Westinghouse Electric Corp., Blairsville, Pa.

Scanlon, J. Kevin, spectrographer, glass research, Pittsburgh Plate Glass Co., Creighton, Pa. [A]

Smith, Robert E., vice-president, Capitol Engineering Corp., Dillsburg, Pa.

ST. LOUIS DISTRICT (9)

Barber, Ira E., superintendent, Ash Grove Lime and Portland Cement Co., Chanute, Kans.

SOUTHEAST DISTRICT (17)

Barrows, Wendell P., secretary, International Chemical & Metallurgical Supply Corp., 906-8 Sweet Bldg., Ft. Lauderdale, Fla. For mail: 2243 Cleveland St., Hollywood, Fla.

Forbes, E. L., chief engineer, utilities, Holston Defense Corp., Kingsport, Tenn.

Greyard, Wilbur B., assistant manager, technical and quality control dept., Wool and Worsted Southern Div., J. P. Stevens & Co., Inc., Milledgeville, Ga.

Moose, J. Blake, director of purchases, Daniel Construction Co., Inc., Box 2286 Greenville, S. C.

SOUTHERN CALIFORNIA DISTRICT (7)

Henry Co., The, Dale H. Stutzman, technical director, 5731 Bickett St., Huntington Park, Calif.

Fretwell, Dan, owner, Aetna Engineering Co., 14106 Aetna St., Van Nuys, Calif. For mail: 15008 Encanto Dr., Sherman Oaks, Calif.

Loveland, Russ A., plant chemist, California Portland Cement Co., Colton, Calif.

Morrison, James H., chief chemist, Kirkhill Rubber Co., 300 E. Cypress, Brea, Calif.

SOUTHWEST DISTRICT (16)

Temco Aircraft Corp., R. W. Ludwig, chief, experimental labs., Box 6191, Dallas, Tex.

Knarr, Robert E., technical director, Halliburton Portland Cement Co., Box 1200, Corpus Christi, Tex.

Wingard, Lester, owner, Wingard Co., Box 1506, Fort Worth, Tex.

WASHINGTON, D. C., DISTRICT (14)

Croft, Don K., director of lab., Baker-Wibberley and Associates, 49 N. Jonathan St., Hagerstown, Md.

Hasty, Stephen Gordon, laboratory director, Automotive Div., Collins & Aikman Corp., Albemarle, N. C. For mail: Route 4, Concord, N. C.

Rasmussen, Paul G., chief structural engineer, Thomas B. Bourne Associates, Inc., 832 Dupont Circle Bldg., Washington 6, D. C.

(*Continued on page 88*)

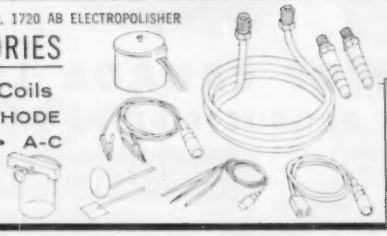
NEW AB ELECTROPOLISHER
FOR
METALLOGRAPHIC
SAMPLES

- SIMPLICITY IN OPERATION
- INTERCHANGEABLE ELECTROLYTE TANK
- IMPACT and CORROSION RESISTANCE
- EASY TO FILL and EMPTY
- CONVENIENT ELECTROLYTE STORAGE
- COMPLETE ELECTRICAL INSULATION
- INCREASED SAMPLE AREA
- GREATER ELECTROLYTE CAPACITY
- VERSATILE POWER SOURCE
- D. C. RIPPLE CONTROL
- FIELD TESTED and APPROVED
- REASONABLY PRICED

No. 1720 AB ELECTROPOLISHER

AVAILABLE ACCESSORIES

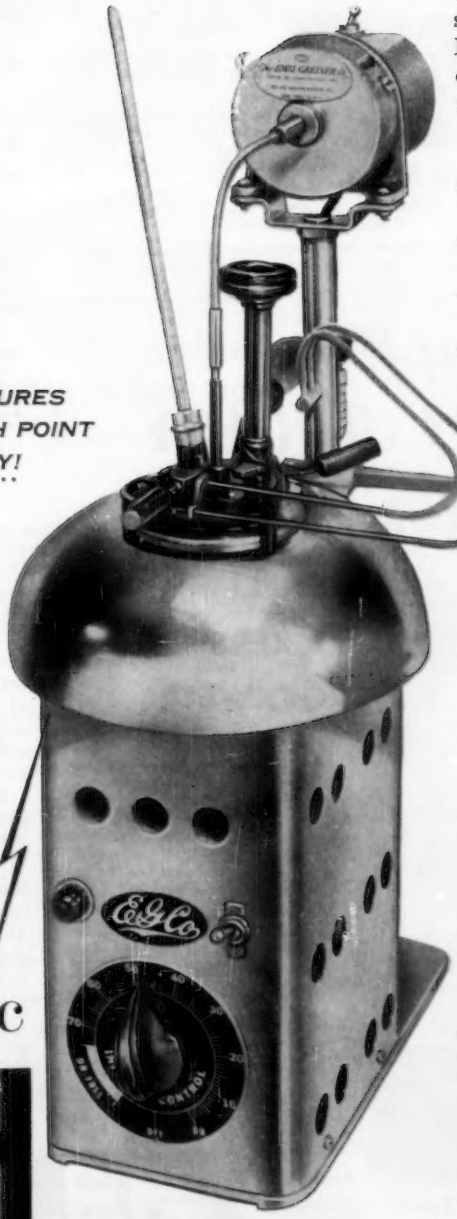
Extra Tanks • Cooling Coils
Extensions: ANODE-CATHODE ETCHING • A-C
Cathodes for Etching
Cathode Holders



Buehler Ltd.
METALLURGICAL APPARATUS
2120 GREENWOOD ST., EVANSTON, ILLINOIS, U.S.A.

FOR FURTHER INFORMATION CIRCLE 811 ON READER SERVICE CARD

NOW!
BRING TEMPERATURES
UP TO FLASH POINT
AUTOMATICALLY!



new
infinite
control
electric

FLASH TESTERS

With a single setting of the dial, new infinite control automatically increases the temperature at a specified rate within the test range. Pointer setting determines number of seconds the heater will be on, as indicated by the pilot light.

PENSKY MARTENS CLOSED TESTER A.S.T.M. D93

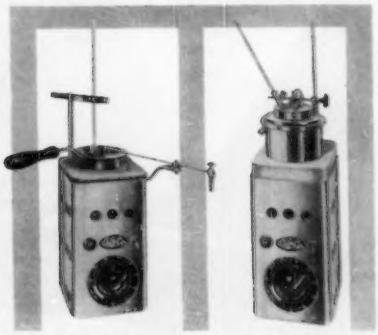
- Temperature increases 9° to 11°F per minute in range of flash point.
- New short flexible shaft on stirrer is positive and easily disconnected.
- New coil for rapid air cooling—perforated tube around the iron casting has a serrated connection to air line.
- New locking device holds cover and cup together . . . is quickly disconnected . . . insures safer operation.
- New stainless steel shell and casing mounted on aluminum base casting.
- 750 W, 110 V AC heater

G-18196
Complete with motor stirrer—**195.00**

TAG CLOSED TESTER A.S.T.M. D56

- Temperature increases 2°F per minute, as specified in method.
- 150 W, 110 V AC heater

G-18181N **110.00**



G-18081 *G-18181N*

CLEVELAND OPEN CUP FLASH TESTER A.S.T.M. D92

- Temperature increases 9° to 11°F per minute in range of flash point.
- New, easily replaceable heating unit.
- Thermometer swings back out of way when not in use.
- 750 W, 110 V AC heater.

Ⓑ *G-18081* **125.00**

E&Co® *The EMIL GREINER Co.* **20-26 N. MOORE STREET DEPT. 229, N. Y. 13, N. Y.**

FOR FURTHER INFORMATION CIRCLE 812 ON READER SERVICE CARD

New Members

(*Continued from page 86*)

Shaw, Henry, chemical engineer, The Babcock & Wilcox Co., 1201 Kemper St., Lynchburg Va. For mail: 125 Easton Ave., Lynchburg, Va. [A]

Watstein, David, engineer, National Bureau of Standards, Washington 25, D. C.

U. S. AND POSSESSIONS

California, University of, Los Alamos Scientific Laboratory Library, Helen F. Redman, librarian, Box 1663, Los Alamos, N. Mex.

OTHER THAN U. S. POSSESSIONS

Aços Villares, S. A., L. D. Villares, president, Rua Pescadores 75, Box 3589, Sao Paulo, Brazil.

Saskatchewan Cement Co., Ltd., Y. Skrypnyk, chief chemist, Box 767, Regina, Sask., Canada.

Barham, Basil Stanley, chief engineer, M. B. John & Hattersley, Ltd., Creswick Rd., Ballarat, Victoria, Australia.

Bylund, K. Gusten, chief metallurgist, Aktiebolaget Järnförädling, Hälleforsnäs, Sweden.

Crawford, Richard L., resident consulting engineer, Tippetts-Abbett-McCarthy-Stratton of Panama and Gibbs & Hill of New York, Apartado 338, Guatemala City, Guatemala.

Delgado A., Oscar A., chemical engineer, Box 188, Cuzo, Peru. [A]

Jentet, Max L., manager, product quality dept., Chausson Co., Asnieres, Siene, France. For mail: 2bis Avenue Roger, Chatou (S & O) France.

Lara M., Carlos, director, Laboratorio de Aguas, Instituto Nacional de Obras Sanitarias, Caracas, Venezuela.

McLaughlan, William, construction engineer, 330 Ninth Ave., W., Calgary, Alta., Canada. [A]

Miller, Ryle L., Jr., project engineer, The Lummus Co., 385 Madison Ave., New York, N. Y. For mail: c/o S. F. I. Lummus, 11 Blvd. Sebastopol, Paris 1 er, France.

Pakistan Ministry of Defence, Chief Administrative Officer, Rawalpindi, Pakistan.

Pluhar, Jaroslav, Výzkumný Ustav Materiálu, Opletalova 25, Prague, Czechoslovakia.

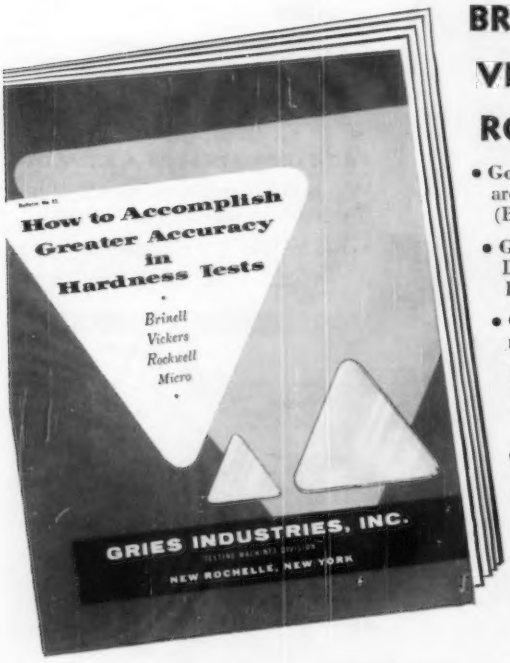
Pomfret, Harry, textile technologist, James Stuttard and Sons, Ltd., 62 Bridge St., Manchester 3, England. For mail: Clover Croft Mills, Higham, near Burnley, Lancs, England.

Rappini, Giorgio Eduardo, chief, research and control lab., Ansaldo S. A., Agenzia Postale Ansaldo, Genoa, Italy.

Rubeli, Maurice, engineer, Distributor, Precision Rubber Products Corp., Dayton 7, Ohio. For mail: Fhg. de l'Hôpital, 35, Neuchatel, Switzerland.

Tricerri, Silvio C., president, Tricerri Grain Corp., 26 Broadway, New York 4, N. Y. For mail: 3 Chemin de Mornex, Lausanne, Switzerland.

how to accomplish
GREATER ACCURACY
in hardness tests



BRINELL
VICKERS
ROCKWELL

- **Government-Certified** Standards of Indentation Hardness (Brinell-Vickers-Rockwell)
- **Government-Certified** Diamond Indentors (Vickers-Knoop-Rockwell)
- **Government-Certified** Dynamometers with Optical Reading by Carl Zeiss Spiral Microscopes, for checking the accuracy of loads in Hardness Testing Machines
- The Grodzinski Double-Cone Diamond Indentation Method and its advantages
- How to obtain Test Data Expressed Directly in Units of Rockwell "C" without using the Rockwell Method with *all its many drawbacks*

This interesting and AUTHORITATIVE booklet is yours for the asking.
It outlines methods . . . advantages . . . some SENSATIONAL results.

All Government certificates mentioned (hardness standards; diamond indentors; optical load indicators) are issued for our account by the Materials Testing Institute, Federal Republic of Germany

Write today for your copy of Bulletin No. 22.

GRIES INDUSTRIES, INC.
Testing Machines Division • New Rochelle 2, N. Y.

FOR FURTHER INFORMATION CIRCLE 813 ON READER SERVICE CARD

Cellulose Institute Established

In February of last year, the State University College of Forestry at Syracuse University, in conjunction with four ASTM company members, established the Cellulose Institute a new frontier for creative science.

In January of this year, J. J. Hermans, professor of physical chemistry and former director of the Laboratory for Inorganic and Physical Chemistry at the University of Leiden, Netherlands, became the Director of the Institute. At present, there are two other full-time personnel, one a research associate from Cornell and a chief chemist from a large pulp and paper company in Finland. The institute eventually expects to have six full-time personnel as well as graduate fellows and assistants.

Among the broad range of problems under consideration, the following are being actively pursued at the present time: acidic dissociation constants of individual glucosides; mechanism of phototendering of cellulose fibers by anthoquinoid dyes; chromophoric intermediates in bleaching reaction of lignosulfonates; and structure of gels on a cellulose basis.

The Cellulose Institute will draw its support from industrial organizations in the cellulose field. Information concerning the scope and present research activities of the Cellulose Institute may be had from E. C. Jahn, associate dean for physical sciences and research, State University College of Forestry at Syracuse University, Syracuse 10, N. Y.

PROUDLY ANNOUNCES ITS . . . .

AMSLER

TESTING MACHINE DIVISION

AMSLER HIGH FREQUENCY VIBROPHORES

The Amsler High Frequency Vibrophore is one of the latest products of this world-renowned manufacturer of physical testing equipment.

It determines the fatigue properties of practically any material under fluctuating and alternating tensile, compressive, shear or torsional stresses.

Simple specimens or test bars, sections of assembled structures or machine components can be tested.

Two sizes of machines cover the load range from 44 to 22,000 lbs. The Vibrophore uses the classic principle of resonance which permits frequencies up to 300 cycles per second while ensuring the accurate maintenance of stresses within 1% of magnitude and time constancy.

The resonance principle also allows convenient determination of other values, such as the damping characteristics of materials under working conditions, or the dynamic modulus of elasticity. Electric furnace and cold chamber attachments allow fatigue tests over a temperature range of −375 F to +1400 F."

Other items in the AMSLER program:

- Static testing machines for loads from 25 grams to 2,500,000 pounds.
- Complete line of fatigue testing machines for loads up to 220,000 pounds.
- Components to build your own testing plant for large structures and assemblies.
- Complete line of concrete testing equipment.
- Microtesting machines based on the AMSLER-CHEVENARD principle.

AMSLER

World-Renowned for Physical Testing Equipment Since 1854 . . . . . Over 200 Different Testing Machines.

carl hirschmann company, inc.

30 Park Avenue, Manhasset, N. Y.

Phone: MAnhasset 7-5300

TWX: Manhasset, N. Y., 1144

BRANCHES:

6015 North Cicero Ave.	Chicago 30, Ill.
18080 James Couzens H'wy.	Detroit, Mich.
5124 Pacific Boulevard	Los Angeles 58, Calif.
5122 Dundas Street, West	Toronto, Canada

CARL HIRSCHMANN COMPANY, INC.
30 Park Avenue
Amsler Testing Machine Division
Manhasset, New York
We are interested in obtaining additional information on Amsler Testing Equipment, more specifically on

. . . . . .

. . . . . .

Your Company: . . . . . .

Address: . . . . . .

Your Name: . . . . . .

Title & Dept.: . . . . . .

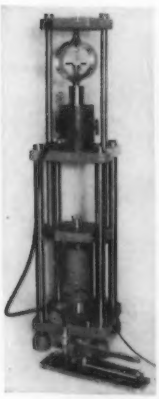
CIRCLE 814 ON READER SERVICE CARD

INACCURACY IS COSTLY!

check your

THRUST STANDS
TESTING MACHINES
DYNAMOMETERS
WEIGHING SYSTEMS

with MOREHOUSE PROVING RINGS



Inaccurate force measurement systems waste time and money. For maximum accuracy, be sure to calibrate your systems regularly with a MOREHOUSE PROVING RING . . . the industry standard for over 30 years. Every MOREHOUSE PROVING RING is calibrated and certified by the National Bureau of Standards.

The MOREHOUSE UNIVERSAL CALIBRATING MACHINE (left) facilitates the calibration of compression and tension type load cells in capacities ranging from 10,000 lb. to 100,000 lb.

Learn the construction, operation and application of proving rings . . . write today for the 16 page book, "THE A B C's of ACCURACY."

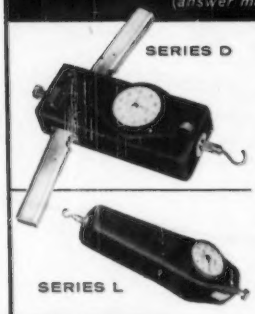
MOREHOUSE MACHINE CO.

1742 Sixth Avenue • York, Pa.

CIRCLE 815 ON READER SERVICE CARD

PRECISION FORCE GAGES

(answer many test standard requirements)



SERIES D

SERIES L

Hunter Mechanical Force Gages are precision-built, direct reading instruments for measuring forces in tension and compression. Are accurate to within 1% of full-scale. "Hold-at-maximum" indicator available as optional feature. Types and sizes available for measuring forces ranging from 0-500 grams to 0-200 pounds.

Standard part of military aircraft kit, Force Gage is a tool for adjustment of controls.

Force Gage is fixture held to test precise electrical assemblies.

Plastics manufacturers use Force Gage to test bond strength of foil coatings on laminates

Thousands of force gages now used for inspection, testing, quality control in labs, on production lines, in the field.

WRITE FOR BULLETIN 750C

HUNTER Springs in Springs

HUNTER SPRING COMPANY

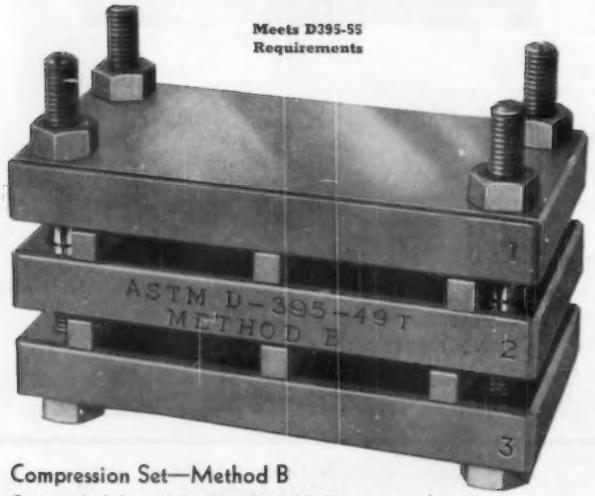
20 Spring Avenue, Lansdale, Pennsylvania

CIRCLE 816 ON READER SERVICE CARD

HOGGSON

TOOLS, MOLDS AND DIES

for rubber testing to ASTM standards



Meets D395-55 Requirements

Compression Set—Method B

Composed of three plates 3" x 6" x 1/4", four compression screws and eight nuts, one set of 12 Spacer Bars, six each .300–.350 and .375–.400. All parts chrome plated.

ONE OF MANY HOGGSON MOLDS AND DIES FOR MAKING STANDARDIZED TEST SAMPLES

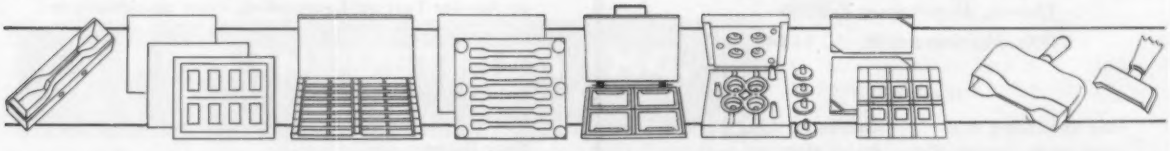
The set at the left is only one of a wide variety of equipment we make for cutting and molding test samples of rubber, plastic, or other synthetic materials for determining adhesion, abrasion, flexing, compression, rebound, etc.

These molds and dies are fabricated of high grade steel and precision finished to recognized ASTM standards of practice. If you will send us your blue prints or tell us what you need, we will send full details without obligation. We also manufacture a full line of production tools for working rubber and plastics.

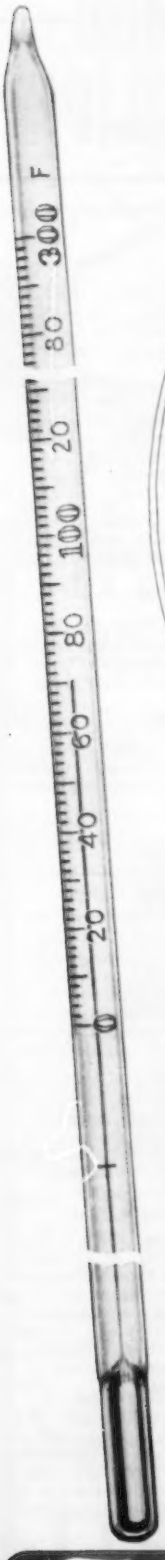
HOGGSON & PETTIS MFG. CO.

133 Brewery St., New Haven 7, Conn.

Pac. Coast: H. M. Royal, Inc., Downey, Calif.



FOR FURTHER INFORMATION CIRCLE 817 ON READER SERVICE CARD



PERMAFUSED PIGMENT IS FOREVER

MAN has told time by the sun's position for ages past. And the markings on our new etched-stem laboratory thermometers will last for ages to come.

The markings on these excellent mercury-filled thermometers have "Legibility That Lasts", because they're made with PERMAFUSED Pigment, which is *fused directly into the glass.* It becomes a part of the glass. The markings will last for the life of the instrument.

Here's what that means for you:

- You can read these thermometers as long as there's light!
- No solution you test will affect the markings —not even organic solvents—except liquids that destroy the glass itself!
- There's no danger of contaminating test solutions with dissolved pigments.

Every Taylor etched thermometer, ASTM, Plain, Armored or Pocket-Type is precision-built and expertly annealed for minimum breakage. The permanent accuracy of the Taylor laboratory thermometer you choose is assured by skilled workmanship and expert aging before pointing. National Bureau of Standards requirements are the basis of design of Taylor thermometers. Special designs are made to order for specific scientific, research and production purposes.

• • •

For further information about PERMAFUSED Pigments, and what they can mean to your laboratory, call your Taylor supplier or write for **Catalog L.** Taylor Instrument Companies, Rochester, N.Y., and Toronto, Ontario.

Taylor Instruments MEAN ACCURACY FIRST

FOR FURTHER INFORMATION CIRCLE 818 ON READER SERVICE CARD

NEWS NOTES ON
Laboratory Supplies and Testing Equipment

Note—This information is based on literature and statements from apparatus manufacturers and laboratory supply houses. The Society is not responsible for statements advanced in this publication.

CATALOGS AND LITERATURE

Bulletin—The Bulletin, a technical and news publication issued quarterly during each year will highlight the work, equipment, and people that make up the Anderson Physical Laboratory.
The Anderson Physical Laboratory 2346

Creep Calculator—The Creep Load Calculator, a pocket-size aid to engineers determines the pounds of weight needed on the weight pan when testing specimens in creep testers.
Arcweld Mfg. Co. 2347

Paper Electrophoresis—An 8-page catalog, SBR-2, describes Model R system for analysis by paper-strip electrophoresis.
Beckman Instruments, Inc. 2348
Spinco Div.

Radioactive Isotope—Publication adds to previous issues an expanded list of carbon-14 compounds and new sections describing heavy water, deuterium and tritium-labeled compounds, and new nitrogen-15 compounds of high isotopic concentration.
BIO-RAD Laboratories 2349

Radioanalytical—Catalogs describe analytical services and instruments for radioactive analytical work.
Controls for Radiation, Inc. 2350

Catalog—New catalog No. 58 contains illustrations and brief descriptions of 50 different units. These units include testing and calibration instruments and fixtures that appear in ASTM, Federal, Military, and other specifications.
Custom Scientific Instruments, Inc. 2351

Plastometer—New catalog 16P1359 describes the plastometer, a device for continuous automatic control of the consistency of fibrous or pulpy slurries.
Fischer & Porter Co. 2352

Laboratory Catalog—New 1958, 112-page Laboratory Catalog describes testing instruments available for paint, paper, plastics, ceramics, food, leather, oil, rubber, and other materials.
Gardner Laboratory, Inc. 2353

Publication—The winter edition of house publication is now ready for distribution; this 8-page tabloid features stories on instrumentation.
Leeds & Northrup Co. 2354

Toggle Switches—New catalog, describes a complete line of toggle and trigger switches. Ten standard types are listed, with illustrations, dimensional and electrical rating data.
Sargent Electric Corp. 2355

Catalog—Recently published, the new issue of Will Lab Log, *No. 2-57*, the latest developments in laboratory instruments and apparatus.
Will Corp. 2356

Insulation Fault Counter for Wire Makers and Users

Accurate Model P-1 continuous insulation tester counts and records pinholes automatically at speeds up to 600 feet per minute. Buzzer also indicates faults. Voltage adjustable to test single or multiple coated wire (0-250 V d-c). Non-damaging 10 microamp test current for reliability and safety—may be adjusted for higher current. Non-destructive type electrode furnished.

Free literature sent. Other dielectric, overvoltage, breakdown, corona, fault counter, continuity, and leakage testers available.

PE PESCHEL ELECTRONICS, INC.

Towners, R.F.D. 1, Patterson, N. Y. • Tel.: TRinity 8-3251

FOR FURTHER INFORMATION CIRCLE 819 ON READER SERVICE CARD

LABORATORY ITEMS

Amplifier—The System D, a 4-channel, galvanometer amplifier package includes power supply. It is well suited for use with wire strain gages, transducers, thermocouples, etc., and will drive even low-sensitivity, high-frequency galvanometers, providing linearity over a wide range of input voltages.
Allegany Instrument Co., Inc. 1520

Pressure Gage—A newly-designed pressure gage which measures pressures up to 100,000 psi can be estimated to closest 250 psi and offers accuracy and maximum safety features.
American Instrument Co., Inc. 1521

Distributometer—The GFB Micron Particle Distributometer is a research, testing, and production control instrument for the continuous indication on a precision-recorder chart of the weight *versus* time of any sample particles in the range of 1 to 100 microns as they accumulate on a balance pan by setting in a liquid.
G. F. Bush Associates 1522

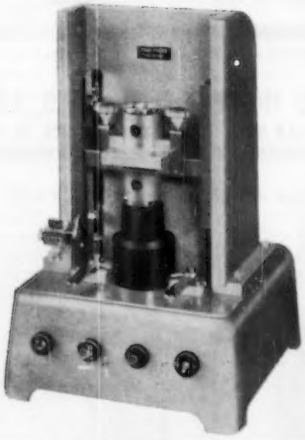
Weathering Tester—Xenotest WPL 394 model is a research, testing, and production control device for accelerating weathering effects of natural sunlight, humidity, rain, and temperature in any repeated program on all materials, coated and otherwise.
G. F. Bush Associates 1523

(*Continued on page 95*)

DON'T BE LEFT HOLDING THE BAG!

measure its paper strength with the

frag-tester



A dynamic, rupture tester for paper and packaging materials which are subjected to energetic strain. A revolutionary new testing method which takes into account the gradual decrease of resistance to strain which widely influences the true usefulness of paper.

Accomplished by a series of impacts rather than one destroying action, this test, when given to a sample, comes closer to duplicating the stress and strain in the handling of wrapping and bag papers than any other tester.

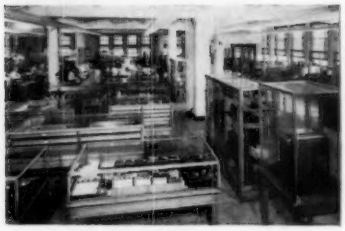
Learn all about it... by writing for complete technical data on the Frag Tester; another addition to the well-known line of TMI instruments.

tmi TESTING MACHINES INC.
72 Jericho Turnpike, Mineola, L. I., N. Y.
Manufacturers and Distributors for over 30 years.

CIRCLE 820 ON READER SERVICE CARD

◀ Main Building

Showroom ▶



Thomas GIVES YOU SUPERIOR SERVICE *because...*

You deal with headquarters

Competent technological staff on call.
Orders filled promptly from vast warehouse.

You draw on large stocks

Three to six months supplies of 22,000 items—mostly pre-packaged—in our stock for immediate shipment.
Widest assortments of Corning, Kimble and Coors items available from any single source.

You select from 1726-page catalogue and supplement

An encyclopedic catalogue and supplement with factual, detailed descriptions—standard reference source throughout the free world.

You save time and money

Extensive pneumatic tube systems and conveyors speed delivery of orders.
More than 92% of orders shipped within two working days after receipt.
Accurate invoices and packing lists.
Substantial packing which keeps breakage to less than 1/20th of 1%.
One-price policy which insures lowest prices to all buyers—advance quotations unnecessary.

You are assured of satisfaction

Stocks carefully selected and continually inspected for quality and performance.
Prompt refund for any item found to be unacceptable for any reason.

ARTHUR H. THOMAS COMPANY
More and more laboratories rely on Thomas / Laboratory Apparatus and Reagents
VINE ST. AT 3RD • PHILADELPHIA 5, PA.

CIRCLE 821 ON READER SERVICE CARD

Oxygen Bomb Sulfur Apparatus

For:

Sulfur in Petroleum Products	ASTM D 129-52
Sulfur in Coal and Coke	ASTM D 271-48
Chlorine in Oils and Greases	ASTM D 808-52T
Sulfur, Halogens, Arsenic, etc. in other Combustible Materials	

The Series 1900 apparatus consists of a Parr self-sealing oxygen bomb with all accessories and instructions for the rapid combustion of analytical samples when calorific measurements are not required.

Order from any Parr Dealer, or write direct for Spec. 1900.

PARR INSTRUMENT CO.
MOLINE, ILLINOIS

CIRCLE 822 ON READER SERVICE CARD

THE ORIGINAL...

Shore DUROMETER

The "International Standard" for testing the hardness of rubber and other elastomeric materials

FEATURES:

- Quadrant or round dial for fast and accurate reading
- Conforms to ASTM D 676-55 T
- Small enough to be carried in the pocket
- Furnished complete with carrying case and standard test block.

The Shore Durometer is available in various models for testing the entire range of rubber hardness.

Write for FREE Descriptive Literature

Made by the manufacturers of the "Scleroscope", for testing the hardness of metals.

Shore INSTRUMENT & MFG. CO., INC.
90-35A VAN WYCK EXPRESSWAY, JAMAICA 35, N. Y.

CIRCLE 823 ON READER SERVICE CARD

KLETT MADE

Colorimeters
Visual
Photo-Electric
Special Types For Testing
Colors Petroleum Products

Glass Color Standards
Glass Cells
Fluorimeter
Nephelometer
Complete Electrophoresis Equipment

KLETT MANUFACTURING COMPANY
Manufacturers of Scientific Instruments
179 East 87th Street New York 28, N. Y.

CIRCLE 824 ON READER SERVICE CARD

Gaertner Quartz-Tube Dilatometer

for precise measurement of thermal expansion

Accurately measures coefficient of linear expansion of specimens up to ½" in diameter and from 2" to 3" long, at temperatures up to 1000° C. Dial gage readings to 0.0001".

Testing procedure described in "Standard Method of Test for Linear Expansion of Metals" (A.S.T.M. Designation: B95) and ". . . of Plastics" A.S.T.M. Designation: B696).

D1200 (above) consists of fused quartz dilatometer with precision dial gage, durably-constructed furnace, control panel with temperature and current indicators, rheostat.

Write for Bulletin 140-53

The Gaertner Scientific Corporation
1215 Wrightwood Ave., Chicago 14, Ill. • Phone: BUckingham 1-5335

CIRCLE 825 ON READER SERVICE CARD

(*Continued from page 92*)

Nicking Jig—A nicking jig, Model CS-92 is offered to the plastic industry. The unit is shown in Fig. 1 of the "Proposed Tentative Method of Test for Environmental Stress Cracking of Ethylene Plastics," which appeared in the ASTM BULLETIN of December 1956. Also available is a Sampler Notcher for ASTM D 256–54 T, Method A and B, as well as many fixtures that appear in ASTM Specifications.
Custom Scientific Instruments, Inc. 1524

Cold Cup—An instrument used for testing the cloud points of liquids, testing the viscosities of oil at low temperatures and for spot chilling.
Rolf Darbo 1525

Thermometer—New thermometer, The Model G, has a head diameter of $1\frac{11}{16}$ in. and is ideally suited for installation on any type of equipment where mounting space is limited.
W. C. Dillon & Co., Inc. 1526

Cylinder Test—Designed especially for job-site use, the new FT-25 cylinder tester with a capacity of 250,000 lb can be easily transported in the trunk compartment of a passenger car.
Forney's Inc. 1527

Chill Chamber—A new 5-cu-ft low-temperature chilling and refrigeration machine offers maximum chamber capacity in minimum floor space. Known as the Model 5L-2, the new unit is compact, requiring only 44 by 30 in. of floor space.
Harris Refrigeration Co. 1528

Fluorometer—A new model of the Galvanek-Morrison Fluorometer now incorporates provision for analysis of liquid samples for trace quantities of both beryllium and uranium.
Jarrell-Ash Co. 1529

Bath—A new constant-temperature bath made of stainless steel inside and outside; working chamber is 13 in. long by 12 in. wide by 7 in. deep. Temperature range up to 100 C.
Labline, Inc. 1530

Scanning System—A completely new system for automatic scanning of paper radio-chromatograms has been announced. The new Actigraph II scans, counts, and records automatically the radioactivity distributed on a strip radio-chromatogram.
Nuclear-Chicago Corp. 1531

Coupling—Designed specifically for precision coupling requirements in servo and instrument applications, the Maxflex miniaturized coupling accommodates radial, axial, and angular misalignment in connecting shafts, motors, and components without blacklash or error.
Parametrics 1532

Temperature Control—A new mercury-actuated Model MFS indicating temperature control designed for all types of industrial applications, features a novel dual mounting design and greatly improved readability.
The Partlow Corp. 1533

Viscosity Bath—A new, complete Temp-Trol kinematic viscosity bath which provides ±0.02 F uniformity allows com-

(*Continued on pgae 96*)

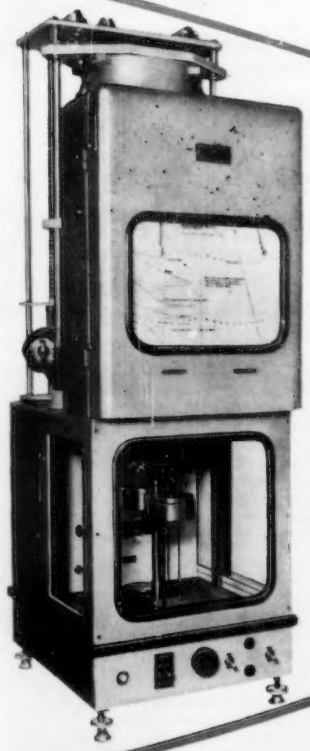
BURRELL *"For Scientists Everywhere"*

STANTON

Thermo-Recording Balance

A superior laboratory balance that heats, weighs and records simultaneously.

"Heat-to-constant-weight" is accomplished easily in research or for process control.



AUTOMATIC ELECTRIC WEIGHT LOADING

WEAR-RESISTANT KNIVES

SAPPHIRE PLANES

FULL AIR-DAMPING

STANTON Thermo-Recording Balance, Model TR-1 Electric weight loading, twin electronic recorder and standard furnace with simple program control. A cam, which can be modified, provides uniform rate of heating. Sensitivity 1 mg.

Burrell Cat. No. 2-569-41.....$4,550.
Price listed is F.O.B. Pittsburgh, Pa.

Other models are available for thermo-recording or recording only with sensitivities of 1 mg. or 0.1 mg.

Ask for Bulletin No. 329

BURRELL CORPORATION
Scientific Apparatus and Laboratory Supplies
2223 FIFTH AVENUE, PITTSBURGH 19, PA.

FOR FURTHER INFORMATION CIRCLE 826 ON READER SERVICE CARD

Lab Items

(*Continued from page 95*)

pletely accurate kinematic viscosity determinations of Newtonian liquids at minimum cost.
Precision Scientific Co. 1534

Centrifuge—New centrifuge with important improvements provide table model performance at a low price.
Precision Scientific Co. 1535

Thermometers—A new method of permanently staining pigment in the glass of laboratory thermometers to make enduring graduated scale markings.
Precision Thermometer and Instrument Co. 1536

Pulse Generator—Model 1020 programmed current pulse generator is a packaged system, providing controlled, fully programmed current pulses for the research, development, and production testing of digital systems and components.
Rese Engineering, Inc. 1537

Load Cells—A new series of precision strain gage load cells, for electrical measurement of forces and weights, incorporates a construction which provides up to 250 per cent greater output with consequent reduction of interference from stray signals.
Revere Corp. of America 1538

Aging Block—A new square design of 28-hole aluminum aging block Model LG is introduced. This tester is an apparatus for testing in accordance with ASTM Methods D 865–54 T and D 471–55 T at temperatures up to 600 F.
Scott Testers, Inc. 1539

Buret—Two new burets with automatic zero called Geyomatic Burets require no lubrication and prevent frozen connections.
Scientific Glass Apparatus Co., Inc. 1540

Insulation Tester for D 257—Stainless steel "silk screen" available with standard electrode patterns, allows application of guarded electrode system for resistivity measurements on all types of specimens.
Semcon 1541

Compression Tester—A new hand-operated tester, Model CT-134 for low capacity compression testing is designed to give utmost accuracy; and to spare the use of much larger testing equipment in low capacity compression testing of materials. Features are: load measuring system is entirely separated from the load applying system, and is completely independent of the weight of any work that is put into the tester.
Steel City Testing Machines, Inc. 1542

Analysis of Steam Mineral Content—Analysis of the mineral content of superheated steam has been made possible by a stainless steel steam sample condenser.
Technical Engineered Products, Inc. 1543

Triaxial Apparatus—This triaxial apparatus is particularly suitable for the accurate determination of stress-strain relations; for the study of soil properties under high pressure; and, for the performance of pore pressure tests. The high capacity triaxial installation is custom made to order.
TESTlab Corp. 1544

Accommodates complete
CREEP RECORDING INSTRUMENTATION
together with VACUUM FURNACE

Creep and stress rupture testing of materials at temperatures to 2000° F., in vacuums to 1 x 10^{-5} mm Hg, can be performed on the Riehle creep testing machine when equipped with a recently developed vacuum furnace. Creep measuring equipment employing electronic recording of specimen strain is provided for this test procedure.

Programmed tests for both creep and relaxation and under vacuum furnace conditions may also be made on the Riehle Universal Testing machines of any capacity with equipment and instruments now available from Riehle.

Convenience in observation and operation is assured because both the elevated temperature equipment and recording instrumentation are designed to function as an integral part of the Riehle machine.

Other Riehle Testing Machines: *Hydraulic and Screw Power Universal Testing Machines, Hydraulic Fatigue Testing Machines, Construction Materials, Impact, Brinell, Torsion, Horizontal Chain, Rope and Cable Testers, Portable Hardness Testers for Rockwell Readings.*

Free Bulletin . . . Mail Coupon

Riehle TESTING MACHINES
A DIVISION OF
American Machine and Metals, Inc.
EAST MOLINE, ILLINOIS
"One test is worth a thousand expert opinions"

RIEHLE TESTING MACHINES
Division of American Machine and Metals, Inc. Dept. AS-258,
East Moline, Illinois
Please send

COMPANY
ADDRESS
CITY ZONE STATE
ATTENTION MR.

INSTRUMENT COMPANY NEWS

Fisher Scientific Co., Pittsburgh, Pa.—Manufacturer-distributor of laboratory instruments and reagent chemicals, opens its ninth plant this September. The new brick and aluminum Philadelphia branch will contain a demonstration laboratory, instrument repair shops, and modern order-handling and technical service facilities.

Plas-Tech Equipment Corp., Waltham, Mass.—A new company serving the plastics and allied industries, has taken up quarters at 751 Main Street, Waltham, Mass. The company manufactures a new high-speed testing machine for measuring tensile, flexural and stress-relaxation properties of materials at exceptionally high rates of loading. Melvin Silberberg and Ross H. Supnik constitute the active management of the corporation.

NEWS OF LABORATORIES

Gordon and Campbell, Morristown, N. J.—Dr. Saul Gordon and Clement Campbell have established a research and development consulting laboratory under the name of Gordon and Campbell, Consulting Chemists, at 12 Brookfield Way, Morristown, N. J. They are specializing in the application of thermoanalytical research techniques such as thermogravimetry, differential thermal analysis and thermovolumetry, including the development of laboratory and control instrumentation.

FOR FURTHER INFORMATION CIRCLE 827 ON READER SERVICE CARD

DEATHS...

W. Earle Buck, retired chief metallurgist, Sheet Div., Continental Steel Corp., Kokomo, Ind., also for many years metallurgist with Granite City Steel Co. and Curtis Manufacturing Co., died January 10, 1958, in his 75th year. Affiliated with ASTM for 40 years, as representative of the companies with whom he was associated, and as a personal member, Mr. Buck was very active in certain of the metals groups. He was a member of Committees A-1 on Steel, A-5 on Corrosion of Iron and Steel, A-6 on Magnetic Properties, E-3 on Chemical Analysis of Metals, and E-7 on Nondestructive Testing for varying periods. For many years he served as chairman of Subcommittee VII on Methods of Testing of Committee A-5. Mr. Buck's loyal, consistent support of ASTM activities was inspiring to his associates and the many close friends he made in the course of his longtime, constructive committee service. Mr. Buck's son, Robert H. Buck, mechanical engineer, Monsanto Chemical Co., Organic Chemicals Div., St. Louis, Mo., also is an ASTM member.

William D. Becker, president, W. F. Becker Associates, engineering consultants, Marine City, Mich. (June, 1957). Member since 1950.

J. W. Deaderick, manager of research, American Lava Corp., Chattanooga, Tenn. (December, 1957). Representative of company membership since 1955, serving on Committees C-21 on Ceramic Whitewares and Related Products, D-9 on Electrical Insulating Materials, and F-1 on Materials for Electron Tubes and Semiconductor Devices; and on several subcommittees of each of these main groups.

Bennett T. Gordon, consulting engineer, Richardson, Gordon and Associates, Philadelphia, Pa. (October 18, 1957). Member since 1954.

Lester T. Smull, vice-president and works manager, Riverside Cement Co., Los Angeles, Calif. (January 16, 1958). A member of the Society since 1951, Mr. Smull had been serving on Committee C-1 on Cement.

Joseph J. White, chief metallurgical engineer, Erie Forge and Steel Corp., Erie, Pa. (October 20, 1957). Representative of Sustaining membership of company since 1956, serving on Committee A-1 on Steel and Subcommittees VI on Steel Forgings and Billets, and XXII on Valves, Fittings, Pipings and Flanges for High-Temperature and Subatmospheric Temperatures, since 1956; and on Committee A-9 on Ferro-Alloys since 1946.

B. D. Thomas Succeeds Clyde Williams at Battelle

The new president of Battelle Memorial Institute, Columbus, Ohio, is B. D. Thomas. He succeeds Clyde Williams, whose retirement was announced recently.

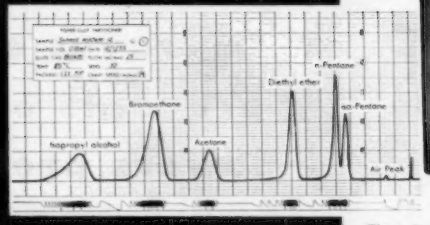
Active head of the Institute since being named a director a year ago, Dr. Thomas has been a member of the Battelle organization for many years. He joined the staff as a research engineer in 1934, was appointed assistant director in 1942, and vice-president in July 1955. In announcing the new appointment, Zay Jeffries, chairman of the Institute's Board of Trustees, commented that the trustees felt they have a proved administrator, as well as an outstanding scholar and scientist who had "won the respect of his colleagues through his rare combination of analytical ability, scientific insight, and clear logic, coupled with a deep sense of human values." "In the next decade science and research will play an increasingly important role in our society" and the Battelle trustees feel that Dr. Thomas is "well trained to lead the Institute to the new responsibilities and new opportunities which are ahead."

now—
more versatile
than ever!

FISHER-GULF
PARTITIONER*

for gas-liquid partition chromatography

for fast, precise quantitative and qualitative analyses of volatile materials



Industrial and Engineering Chemistry calls partition chromatography "the greatest advance in analysis of volatile petroleum constituents . . . since the adoption of spectroscopic methods."

THIS BULLETIN TELLS
"HOW AND WHY"

This 8-page bulletin shows the Partitioner's potential value for analytical control of petroleum products, gas and liquid fuels, plant effluent gases, commercial solvents, many other industrial and research uses.

WRITE FOR YOUR COPY:
107 FISHER BUILDING
PITTSBURGH 19, PA.

*Trade-mark. Developed by petroleum specialists in the Gulf Research and Development Company; refined in the Fisher Development Laboratories.

B-4b

Since it was introduced a year ago, the Fisher-Gulf Partitioner has proved itself one of the most reliable and versatile instruments for qualitative and quantitative analysis by gas chromatography.

The Partitioner is a completely automatic instrument which makes the fullest use of the basic advantages of partition chromatography: high speed . . . high resolution . . . micro samples . . . qualitative and quantitative determinations . . . plus extreme flexibility.

Yet, with all these advantages, Fisher scientists still continue working to make the Partitioner even more versatile. Their latest results are listed below.

5 *new features—*

NEW STAINLESS STEEL COLUMNS enable analysis of many corrosives not analyzable accurately with copper columns.

SECOND COLUMN may be installed in parallel with the first; two-position valve allows use of either column at will.

NEW PRECISION INJECTION SYSTEM enables operator to reproduce the smallest sample volumes within ±0.3% for liquids and 0.8% for gases.

ADJUSTABLE SENSITIVITY STOPS enable exact reproduction of low and high sensitivity settings in successive runs.

QUICKER EQUILIBRIUM is reached through the use of higher-wattage electric heaters.

FISHER SCIENTIFIC

America's Largest Manufacturer-Distributor of Laboratory Appliances & Reagent Chemicals

IN THE U.S.A.			IN CANADA
Boston	Chicago	Philadelphia	Edmonton
Buffalo	Cleveland	Pittsburgh	Montreal
Charleston, W.Va.	Detroit	St. Louis	Toronto
	New York	Washington	

FOR FURTHER INFORMATION CIRCLE 828 ON READER SERVICE CARD

ASTM Standards Approved as American Standard by American Standards Assn.

STEEL (Approved Aug. 30)

Specifications for Welded Steel Wire Fabric for Concrete Reinforcement (ASTM A 185 – 56 T; ASA G45.1-1957)

STEEL (Approved January 2)

Specification for Billet-Steel Bars for Concrete Reinforcement (ASTM A 15 – 57 T; ASA A50.1-1958)

Specification for Rail-Steel Bars for Concrete Reinforcement (ASTM A 16 – 57 T; ASA A50.2-1958)

Specification for Mild- to Medium-Strength Carbon-Steel Castings for General Application (ASTM A 27 – 57; ASA G50.1-1958)

Specification for Forged or Rolled Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service (ASTM A 105 – 57 T; ASA G17.3-1958)

Specification for High-Strength Steel Castings for Structural Purposes (ASTM A 148 – 57; ASA G52.1-1958)

Specification for Axle-Steel Bars for Concrete Reinforcement (ASTM A 160 – 57 T; ASA G43.1-1958)

Specification for Forged or Rolled Steel Pipe Flanges, Forged Fittings, and Valves and Parts for General Service (ASTM A 181 – 57 T; ASA G46.1-1958)

Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service (ASTM A 182 – 57 T; ASA G37.1–1958)

Specification for Carbon-Silicon Steel Plates of Intermediate Tensile Ranges for Fusion-Welded Boilers and Other Pressure Vessels (ASTM A 201 – 57 T; ASA G31.1-1958)

Specification for Molybdenum-Steel Plates for Boilers and Other Pressure Vessels (ASTM A 204 – 57; ASA G34.1-1958)

Specification for High Tensile Strength Carbon-Silicon Steel Plates for Boilers and Other Pressure Vessels (ASTM A 212 – 57 T; ASA G35.1-1958)

COPPER AND COPPER ALLOYS (Approved January 2)

Specification for Seamless Copper Pipe, Standard Sizes (ASTM B 42 – 57; ASA H26.1-1958)

Specification for Seamless Red Brass Pipe, Standard Sizes (ASTM B 43 – 57; ASA H27.1-1958)

MANUFACTURED MASONRY UNITS (Approved January 2)

Specification for Structural Clay Load-Bearing Wall Tile (ASTM C 34 – 57; ASA A74.1-1958)

Specification for Structural Clay Non-Load-Bearing Tile (ASTM C 56 – 57; ASA A76.1-1958)

Specification for Structural Clay Floor Tile (ASTM C 57 – 57; ASA A77.1-1958)

Specification for Building Brick (Solid Masonry Units Made from Clay or Shale) (ASTM C 62 – 57; ASA A98.1-1958)

Methods of Sampling and Testing Brick (ASTM C 67 – 57; ASA A82.1-1958)

Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale) (ASTM C 216 – 57; ASA A99.1-1958)

GYPSUM (Approved January 2)

Specification for Gypsum Plasters (ASTM C 28 – 57; ASA A49.3-1958)

Specification for Inorganic Aggregates for Use in Gypsum Plaster (ASTM C 35 – 57 T; ASA A107.1-1958)

REFRACTORIES (Approved January 2)

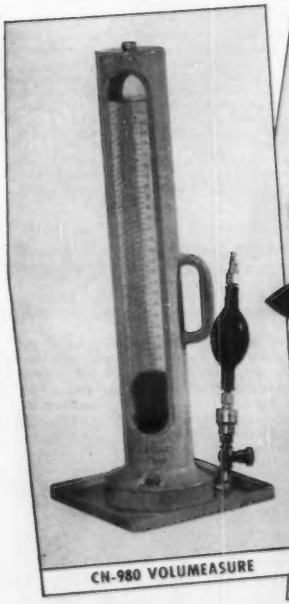
Classification of Insulating Fire Brick (ASTM C 155 – 57; ASA A111.22-1958)

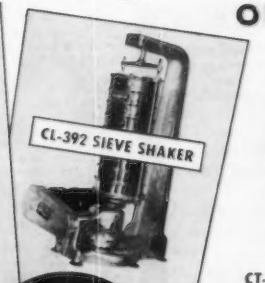
(*Continued on page 100*)

ACCURATE
LABORATORY OR JOB-SITE
TESTING...

improves quality control
prevents over-design
lowers project costs

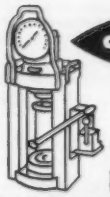
ON ALL CONSTRUCTION!

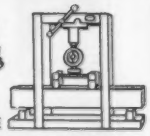


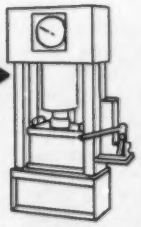


soils

concrete







asphalt

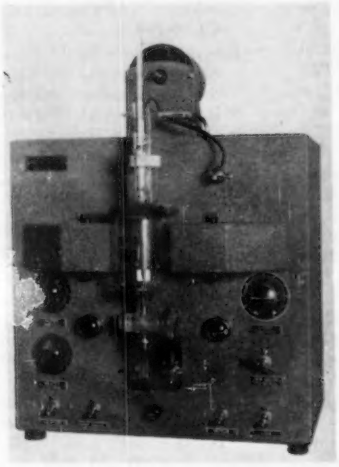
Engineering Test Apparatus for Soils, Construction Materials, Concrete and Asphalt ranging from single items to self-contained Mobile Laboratories are available for immediate shipment.

SOILTEST Incorporated

EASTERN OFFICE
60 EAST 42nd ST., NEW YORK 17, N. Y.
TELEPHONE YUkon 6-7383

4711 WEST NORTH AVENUE · CHICAGO 39, ILLINOIS, U.S.A.

FOR FURTHER INFORMATION CIRCLE 829 ON READER SERVICE CARD



KOEHLER AUTOMATIC ANILINE POINT APPARATUS

New 600 Series with Increased Sensitivity and Versatility

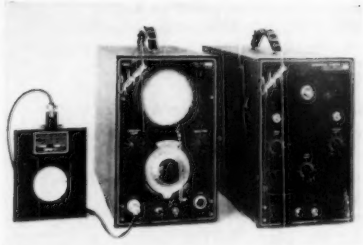
Arrives at aniline point automatically
Holds at exact aniline point until recorded by operator
Temperature Range from 21 to 220 F.
Average time required for each test—less than five minutes
Cleaning of pyrex cell accomplished without removing from instrument
For descriptive folder write your laboratory supply dealer or direct to

KOEHLER INSTRUMENT COMPANY INC.
168-56 Douglas Ave. Jamaica 33, N. Y.
Manufacturer of Petroleum Testing Equipment

CIRCLE 830 ON READER SERVICE CARD

DICE DOES IT BETTER!

For Unscrambling Metal Mixups



THE CYCLOGRAPH MODEL C

This instrument permits truly high speed, non-destructive sorting of raw, semi-finished or finished parts by their metallurgical characteristics. With the new Automatic Sorter Unit speeds up to 300 pieces per minute are possible with the use of suitable feeding equipment. Used by leading industrial firms everywhere.

Non-destructive Testing and Measuring Instruments

J. W. DICE CO., ENGLEWOOD 11, NEW JERSEY
In Canada: Non Destructive Testing Corp. Ltd., Toronto.

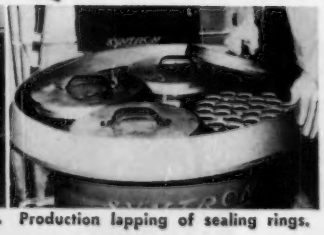
CIRCLE 831 ON READER SERVICE CARD

SYNTRON Lapping Machines

GIVE YOU:

- Metallographic finishes
- Precision flatness
- In production quantities

for easier lapping and polishing of parts and samples with more uniform results.



Loading with metallic sealing rings. Production lapping of sealing rings.

SYNTRON Lapping Machines provide a simple, easy mechanical way to lap and polish samples and parts.

Produce lap flat surfaces and metallographic finishes with absolute uniformity in production quantities.

Simplicity of design with no obstructions makes loading and unloading easy. Highspeed controlled vibration provide more effective lapping with low maintenance.

Lap parts and samples easy in production quantities with SYNTRON Lapping Machines.

TS258

SYNTRON COMPANY
444 Lexington Avenue Homer City, Penna.

FOR FURTHER INFORMATION CIRCLE 832 ON READER SERVICE CARD

ASA Approvals

Continued from page 98)

RUBBER (Approved January 2)

Methods of Sample Preparation for Physical Testing of Rubber Products (ASTM D 15 – 57 T; ASA J1.1-1958)

PAINT PIGMENTS (Approved January 2)

Methods for Chemical Analysis of Dry Mercuric Oxide (ASTM D 284 – 57 T; ASA K59.1-1958)

Method of Test for Tinting Strength of White Pigments (ASTM D 332 – 57 T; ASA K56.1-1958)

ELECTRICAL INSULATING MATERIALS (Approved January 2)

Methods of Testing Laminated Tubes Used for Electrical Insulation (ASTM D 348 – 56; ASA C59.14-1958)

Methods of Testing Laminated Round Rods Used for Electrical Insulation (ASTM D 349 – 56; ASA C59.15-1958)

Method for Sampling Electrical Insulating Oils (ASTM D 923 – 56; ASA C59.21-1958)

Specification for Natural Block Mica and Mica Films Suitable for Use in Fixed Mica-Dielectric Capacitors (ASTM D 748 – 54 T; ASA C59.26-1958)

ELECTRICAL INSULATING MATERIAL (Approved Oct. 31)

Specification for Natural Muscovite Mica Based on Visual Quality (ASTM D 351 – 57 T; ASA C59.27-1957)

BARE ELECTRICAL CONDUCTORS (Approved Nov. 27)

Specification for Soft or Annealed Copper Wire (ASTM B 3 – 56; ASA C7.1-1957)

Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft (ASTM B 8 – 56; ASA C7.8-1957)

Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes (ASTM B 33 – 56 T; ASA C7.4-1957)

Specification for Copper Bus Bar, Rod, and Shapes (ASTM B 187 – 55; ASA C7.25-1957)

Specification for Seamless Copper Bus Pipe and Tube (ASTM B 188 – 56; ASA C7.26-1957)

Specification for Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes (ASTM B 189 – 56 T; ASA C7.15-1957)

Specification for Cored, Annular, Concentric Lay-Stranded Copper Conductors (ASTM B 226 – 56; ASA C7.16-1957)

Specification for Concentric-Lay-Stranded Copper Covered Steel Conductors (ASTM B 228 – 56; ASA C7.18-1957)

Specification for Concentric-Lay-Stranded Copper and Copper Covered Steel Composite Conductors (ASTM B 229 – 56; ASA C7.19-1957)

Specification for Tinned Hard-Drawn and Medium-Hard-Drawn Copper Wire for Electrical Purposes (ASTM B 246 – 56 T; ASA C7.37-1957)

Specification for Three-Quarter Hard Aluminum Wire for Electrical Purposes (ASTM B 262 – 56; ASA C7.35-1957)

Method for Determination of Cross-Sectional Area of Stranded Conductors (ASTM B 263 – 56 T; ASA C7.29-1957)

Specification for Silver-Coated Soft or Annealed Copper Wire (ASTM B 298 – 56 T; ASA C7.38-1957)

PETROLEUM PRODUCTS AND LUBRICANTS (Approved Nov. 18)

Method of Test for Melting Point of Paraffin Wax (ASTM D 87 – 57; ASA Z11.4-1957)

Method of Test for Flash and Fire Points by Cleveland Open Cup (ASTM D 92 – 57; ASA Z11.6-1957)

Method of Test for Cloud and Pour

ELECTRONIC BALANCER

MODEL SU-6 ELECTRONIC BALANCER HANDLES ANY ROTATING BODY from 4 ounces to 100 pounds. Diameters to 20 inches.

Requiring minimum space, minimum fixturization, and featuring extreme simplicity of operation, the SU-6 Dynamic Balancer is completely electronic in both detection and location of unbalance. It provides direct, precise reading of magnitude and position of unbalance. For manufacturers and shops seeking a precision machine with great range and versatility, the SU-6 offers the very finest characteristics at the lowest price available!

WRITE FOR COMPLETE INFORMATION.

M-B MICRO BALANCING, INC.
Herricks Road, Garden City Park, N. Y.
Most Famous Name in Dynamic Balancers

CIRCLE 833 ON READER SERVICE CARD

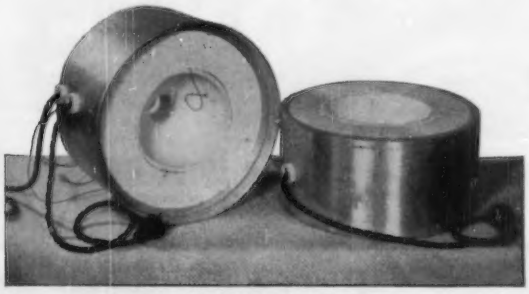
At What Temperatures Do Liquids Self-Ignite?

If you know the self-ignition temperatures of combustible liquids, you can develop more effective protective measures against fire hazards.

The SETCHKIN SELF-IGNITION APPARATUS will determine those temperatures for you. It consists in part of an insulated spherical flask, designed to provide conditions favorable to low ignition temperature values. It is well insulated to prevent loss, and capable of obtaining reproducible results.

Write for free bulletin that discusses fully testing procedure with the SETCHKIN SELF-IGNITION APPARATUS and test results on numerous combustible liquids.

RESEARCH APPLIANCE COMPANY
Box 307 Allison Park, Pa.



CIRCLE 834 ON READER SERVICE CARD

Points (ASTM D 97 – 57; ASA Z11.5-1957)

Method of Test for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (ASTM D 240 – 57 T; ASA Z11.14-1957)

Def. of Terms Relating to Petroleum (ASTM D 288 – 57; ASA Z11.28-1957)

Method of Test for Existent Gum in Fuels by Jet Evaporation (ASTM D 381 – 57 T; ASA Z11.36-1957)

Method of Test for Distillation of Plant Spray Oils (ASTM D 447 – 57 T; ASA Z11.43-1957)

Method for Conversion of Kinematic Viscosity to Saybolt Furol Viscosity (ASTM D 666 – 57; ASA Z11.53-1957)

Method of Test for Oxidation Stability of Aviation Fuels (ASTM D 873 – 57 T; ASA Z11.60-1957)

Method of Test for Sulfated Residue from New Lubricating Oils (ASTM D 874 – 57 T; ASA Z11.68-1957)

Method of Test for Olefinic Plus Aromatic Hydrocarbons in Petroleum Distillates (ASTM D 1019 – 57 T; ASA Z11.71-1957)

Method of Test for Water Tolerance of Aviation Fuels (ASTM D 1094 – 57; ASA Z11.82-1957)

Method of Test for Analysis of 60 Octane Number Isooctane-Normal Heptane ASTM Knock Test Reference Fuel Blends by Infrared Spectrophotometry (ASTM D 1095 – 54; ASA Z11.94-1957)

Method of Test for 1,3-Butadiene in C_4 Hydrocarbon Mixtures by Ultraviolet Spectrophotometry (ASTM D 1096 – 54; ASA Z11.95-1957)

Method of Test for Density and Specific Gravity of Liquids by Bingham Pycnometer (ASTM D 1217 – 54; ASA Z11.96-1957)

Method of Test for Unsaturated Light Hydrocarbons (Silver-Mercuric Nitrate Method) (ASTM D 1268 – 55; ASA Z11.97-1957)

TEXTILES (Approved Nov. 18)

Method of Test for Resistance to Yarn Slippage in Silk, Rayon, and Acetate Woven Fabrics (ASTM D 434 – 42; ASA L14.102-1957)

Method of Test for Yarn Distortion in Woven Fabrics (ASTM D 1336 – 54 T; ASA L14.103-1957)

Method of Test for Length and Length Distribution of Cotton Fibers by the Array Method (ASTM D 1440 – 55; ASA L14.91-1957)

Methods of Sampling Cotton Fibers for Testing (ASTM D 1441 – 54; ASA L14.92-1957)

Method of Test for Fiber Weight per Unit Length and Maturity of Cotton Fibers (Array Method) (ASTM D 1442 – 54; ASA L14.93-1957)

Method of Test for Maturity of Cotton Fibers (Random Sample Sodium Hydroxide Swelling Method) (ASTM D 1443 – 56; ASA L14.94-1957)

Method of Test for Cross-Sectional Characteristics of Cotton Fibers (ASTM D 1444 – 56; ASA L14.95-1957)

Method of Test for Strength of Cotton Fibers (Flat Bundle Method) (ASTM D 1445 – 57; ASA L14.96-1957)

Method of Test for Number of Neps in Cotton Fibers (ASTM D 1446 – 53 T; ASA L14.97-1957)

Method of Test for Length of Cotton Fibers by Fibrograph (ASTM D 1447 – 54 T; ASA L14.98-1957)

Method of Test for Fineness of Cotton Fibers by Micronaire (ASTM D 1448 – 56; ASA L14.99-1957)

Method for Determining the Specific Area and Immaturity Ratio of Cotton Fibers (Arealometer Method) (ASTM D 1449 – 55 T; ASA L14.100-1957)

Method of Test for Maturity of Cotton Fibers (Polarized-Light Method) (ASTM D 1450 – 57; ASA L14.101-1957)

NEW Sargent ELECTRIC HEATER

- Seven Step Control
- Low Cost
- Stainless Steel Construction
- Localized Heating
- Up to 750 Watt Output

S-40340 HEATER—Electric, Seven Step, Stainless Steel, 750 Watt, Sargent. An economical well constructed heater for laboratory use in distillations, evaporations, digestions and extractions; applicable for use in many standard A.S.T.M. methods such as D-86 and in the official Kjeldahl method of the A.O.A.C.

The heater is equipped with three Chromel-A heating elements of 150, 250 and 350 watts, spirally positioned in increasing order of size from center of lower element refractory, assuring uniform heating at all ranges.

The selective or combined use of these heating elements provide seven operating ranges, namely, 150, 250, 350, 400, 500, 600 and 750 watts. The heating elements are energized by three toggle switches located on the control panel. A panel plate clearly indicates which toggle switch must be thrown to obtain the desired wattage.

The entire heating unit is contained in a refractory plate isolated from the outer frame insuring that the stainless steel case is cool at all times.

Removable upper refractory is reversible. One side molded to accommodate 500 ml and 800 ml Kjeldahl flasks and 4 in. concentric metal rings. The other side beveled to accommodate large, round-bottom flasks.

Complete with S-40546 lower refractory, S-40547 upper refractory, one pair of dovetail clamp sockets, one S-40745 dovetail clamp and cord and plug for attachment to standard outlets. For operation from 115 volt, A.C. or D.C. circuits..... $28.00

SARGENT

SCIENTIFIC LABORATORY INSTRUMENTS • APPARATUS • SUPPLIES • CHEMICALS

E. H. SARGENT & COMPANY, 4647 W. FOSTER AVE., CHICAGO 30, ILLINOIS
MICHIGAN DIVISION, 8560 WEST CHICAGO AVENUE, DETROIT 4, MICHIGAN
SOUTHWESTERN DIVISION 5915 PEELER STREET, DALLAS 35, TEXAS
SOUTHEASTERN DIVISION, 3125 SEVENTH AVE., N., BIRMINGHAM 4, ALA.

FOR FURTHER INFORMATION CIRCLE 835 ON READER SERVICE CARD

Federal Government Standards Index Changes

THE General Services Administration of the Federal Supply Service is charged with the responsibility for establishing specifications to be used by the Federal Government for procurement of materials and supplies. The GSA issues an annual Index of Initiation of Federal Specifications Projects as of March 1, and monthly supplements.

The items listed below appeared in Supplement No. 9 for the month of November 1957.

INITIATIONS:

Title	Type of Action	Symbol or Number	FSC Code	FSSC Class	Assigned Agency & Preparing Activity
Cloth, Cotton, Sheeting, Unbleached Narrow	New	CCC-C-432	8305	83	DOD-Army-QMC
Film, Radiographic, Industrial and Medical	New	W-F-00350 (Navy-Ships)	6525-6535	18	DOD-Navy-Ships
Funnels, Glass, Fluted or Ribbed	Rev. Rev.	DD-F-796 DD-F-00796a (GSA-FSS)	6640	..	GSA-FSS
Funnels, Glass, Smooth (Chemical)	Rev.	DD-F-806 & DD-F-00806a (GSA-FSS)	6640	..	
Primer-Surfacer; Synthetic Tints and White	Rev.	TT-P-659a	8010	52	DOD-Army-Ord
Solder; Lead Alloy, Tin Lead Alloy, and Tin Alloy; Flux Cored Ribbon and Wire, and Solid Form	Am.	QQ-S-571	..	..	DOD-Army-SigC
Steel Bars, Shapes and Forgings—Corrosion Resisting	Am. 1	QQ-S-763b	9510	..	GSA-FSS
Wax, General Purpose, Solvent Type	Rev. Rev.	P-W-158 & P-W-00158a (GSA-FSS)	7930	..	GSA-FSS GSA-FSS

PROMULGATIONS:

Title	Type of Action	Symbol or Number
Aluminum Alloy Bars, Rods, and Structural and Special Shaped Sections, Extruded, 6063 (63S)	New	QQ-A-274
Aluminum Alloy Plate and Sheet, Alclad 7075 (Superseding Fed. Spec. QQ-A-287)	Rev.	QQ-A-287a
Brass, Leaded and Non-Leaded; Rods, Shapes, Forgings and Flat Products with Finished Edges (Bars, Flat Wire and Strips) (Superseding FS QQ-B-626 & FS QQ-B-613 (In Part))	Rev.	QQ-B-626a
Cellulose Acetate Plastic Sheets	Am. 1	L-C-169
Cleaning Solutions, Porcelain (Superseding IFS P-P-00586(GSA-FSS) Rev. 1)	New	P-C-450
Flux, Soldering; Paste and Liquid (Superseding IFS O-F-0050a(Navy) & FS O-F-506)	Rev.	O-F-506b
Lubricants, Liquid Fuels, and Related Products; Methods of Testing	(Chg.Not.2) Fed.Test	Met.Std. 791
Magnesium Alloy, Permanent and Semi-Permanent Mold Castings (Superseding FS QQ-M-55)	Rev.	QQ-M-55a
Molding Plastic, Acrylic	New	L-M-500
Naval Brass; Plate, Rolled Bar, Sheet and Strip (Superseding FS QQ-B-638(In Part))	New	QQ-N-30
Naval Brass; Rods, Bars, Wire, Shapes and Forgings and Flat Products with Finished Edges (Superseding FS QQ-B-636b & FS QQ-B-628 (In Part))	New	QQ-N-35
Soap, Scouring, Cake Form (Superseding FS P-S-571b)	Rev.	P-S-571c
Steel Bars, Alloy, Cold Finished and Hot Rolled, (General Purpose) (Superseding FS QQ-S-624)	Rev.	QQ-S-624a
Textile Test Methods	Am. 4 (Part 2)	CCC-T-191b
Tube, Connecting, Laboratory Glassware and Connector, Elastic Tubing, Branched	New	DD-T-710
Union, Pipe, Steel or Malleable Iron, Threaded Pipe Connection, 250 p.s.i. WSP; 500 p.s.i. WOG (Cold, Nonshock)	Rev.	WW-U-531a
Vinyl Chloride Polymer and Copolymer Rigid Sheets	Am. 2	L-V-351

THE Mettler H-4
MULTI-PURPOSE BALANCE

is ideal for control weighings accurate to 1 milligram.

VITAL STATISTICS:

CAPACITY: 160 G
RANGE OF OPTICAL SCALE: 1 G
ONE SCALE DIVISION IS 10 MG
EASY VERNIER READING TO 1 MG

And remember: The set of weights is built into the balance. No loose weights are used.

WRITE TODAY FOR FULL INFORMATION ON THIS AND OTHER METTLER BALANCES AND PRECISION SCALES.

Mettler INSTRUMENT CORPORATION
HIGHTSTOWN, N. J.

FOR FURTHER INFORMATION CIRCLE 836 ON READER SERVICE CARD

INTERIM FEDERAL SPECIFICATIONS ISSUED:

Title	Type of Action	Symbol or Number
Cloth, Cotton, Bunting, Mercerized	New	CCC-C-00439(GSA-FSS)
Mortars and Pestles (Glass and Porcelain)	Rev.	GG-M-00621a(HEW-PHS)
Roofing Felt, Glass Fiber, Asphalt Saturated, Uncoated (For Flashing and Roofing)	New	SS-R-00620(GSA-FSS)
Sodium Borate Decahydrate, Technical (Borax)	New	SS-S-00535 (GSA-FSS)
Tape, Pressure-Sensitive, Adhesive (Cellophane and Cellulose Acetate)	Rev.	L-T-0090b (GSA-FSS)
Watch Glasses, Laboratory	Rev.	DD-W-0013b(HEW-PHS)

CANCELLATIONS:

Title	Symbol or Number	Reason for Cancellation
Compound: Cleaning, Soap-Abrasive-Type (For Painted Surfaces)	P-C-565	Superseded by Fed. Spec. P-C-442

INDEX TO ADVERTISERS

ACCURACY SCIENTIFIC INSTRUMENT CO. 80
AMERICAN CHAIN & CABLE CO. 84
WILSON MECHANICAL INSTRUMENT DIV.
ATLAS ELECTRIC DEVICES CO. 78
ATOMIC ENERGY OF CANADA, LTD. 85

BALDWIN-LIMA-HAMILTON 2, 3
BUEHLER, LTD. 86
BURRELL CORPORATION 95

CENTRAL SCIENTIFIC CO. 83

DELTA CHEMICAL WORKS 103
DICE, J. W., CO. 99

EASTMAN KODAK CO. 75
EBERBACH CORP. 80

FISHER SCIENTIFIC CO. 97

GAERTNER SCIENTIFIC CO. 94
GENERAL RADIO CO. . . . . Inside Back Cover
GREINER COMPANY, THE EMIL 87
GRIES, INDUSTRIES, INC. 88

HARSHAW SCIENTIFIC 79
HIRSCHMANN, CO., INC., CARL 89
HOGGSON & PETTIS MFG. CO. 90
HUNTER SPRING COMPANY 90

INSTRON ENGINEERING CORP. . . . . Inside Front Cover

KLETT MFG. CO. 94
KOEHLER INSTRUMENT COMPANY, INC. 99

METTLER INSTRUMENT CORP. 102
MIRCO BALANCING, INC. 100
MOOREHOUSE MACHINE COMPANY 90

NUCLEAR CHICAGO CORP. 81

OLSEN TESTING MACHINE CO., TINIUS . . . . . Outside Back Cover

PARR INSTRUMENT CO. 94
PERKINS & SON, INC., B. F. 103
PESCHEL ELECTRONICS, INC. 92

RADIO CORPORATION OF AMERICA 4
RESEARCH APPLIANCE CO. 100
RIEHLE TESTING MACHINES 96

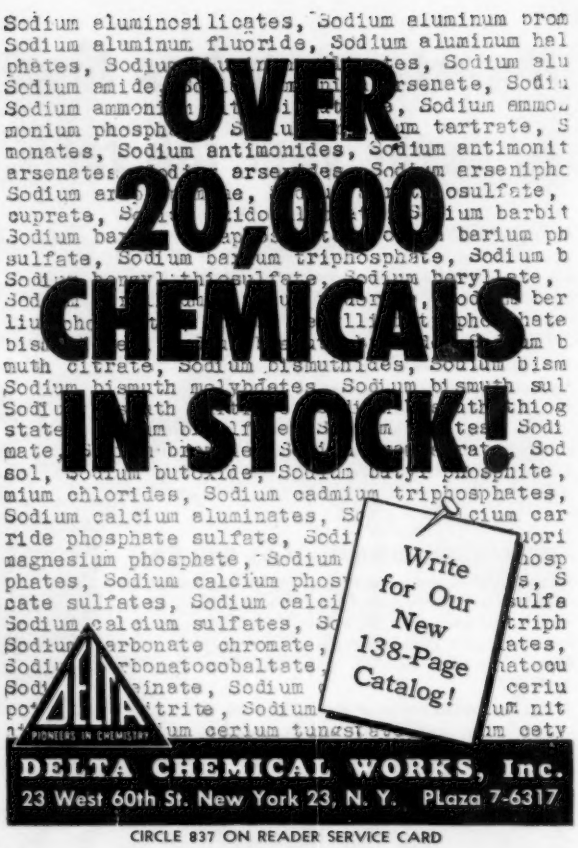
SARGENT & CO., E. H. 101
SCOTT TESTERS, INC. 76
SHORE INSTRUMENT & MFG. CO., INC. 94
SOILTEST, INC. 98
SYNTRON COMPANY 99

TATNALL MEASURING SYSTEMS COMPANY
A SUBSIDIARY OF THE BUDD COMPANY 77
TAYLOR INSTRUMENT COS. 91
TESTING MACHINES, INC. 93
THOMAS CO., ARTHUR H. 93
THWING-ALBERT INSTRUMENT CO. 82

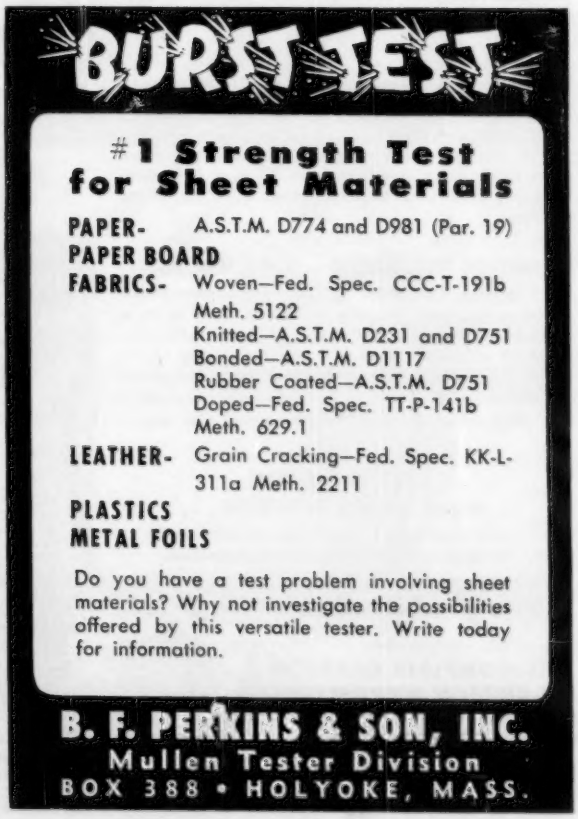
UNITED SCIENTIFIC CO. 104

WILSON MECHANICAL INSTRUMENT DIV.
AMERICAN CHAIN AND CABLE CO. 84

PROFESSIONAL CARDS 72, 73, 74



CIRCLE 837 ON READER SERVICE CARD


BURST TEST
#1 Strength Test for Sheet Materials
PAPER- A.S.T.M. D774 and D981 (Par. 19)
PAPER BOARD
FABRICS- Woven—Fed. Spec. CCC-T-191b Meth. 5122
Knitted—A.S.T.M. D231 and D751
Bonded—A.S.T.M. D1117
Rubber Coated—A.S.T.M. D751
Doped—Fed. Spec. TT-P-141b Meth. 629.1
LEATHER- Grain Cracking—Fed. Spec. KK-L-311a Meth. 2211
PLASTICS
METAL FOILS
Do you have a test problem involving sheet materials? Why not investigate the possibilities offered by this versatile tester. Write today for information.
B. F. PERKINS & SON, INC.
Mullen Tester Division
BOX 388 • HOLYOKE, MASS.

CIRCLE 838 ON READER SERVICE CARD

It costs much less than you think . . .
to outfit your lab for every type of microscopy!

The proof is a matter of simple arithmetic. For example, for as little as $666.95 — often the cost of a single microscope alone — you may purchase *four* UNITRON microscopes and a photomicrography set. Shown here is a small selection of the many UNITRON models available.

METALLURGICAL POLARIZING BRIGHT-FIELD
STEREOSCOPIC PHASE PHOTOMICROGRAPHY

UNITRON POLARIZING — NEW Model MPS

For studying optical properties of specimens. Triple-lens, focusable condenser with swing-out top elements and iris diaphragm. Bertrand lens for examination of interference figures. Two compensation plates. Revolving graduated stage. Coarse and fine focusing. Centerable, strain-free objectives, 4X, 10X, 40X. Eyepieces, micrometer 5X and cross-hair 15X.

MPS $269

UNITRON METALLURGICAL — Models MMU, MMA

MMU: for metals and opaque specimens and also transparent specimens under both ordinary and polarized light. Vertical, oblique and transmitted illumination. Transformer housed in microscope base. Focusable stage, polarizing apparatus and filters. Objectives: 5X, 10X, 40X, 100X. Eyepieces: P5X, P10X, K15X.

MMA: a simplified version of MMU, 25 – 600X.

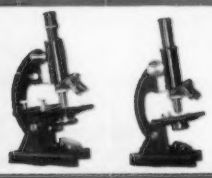
MMU $287
MMA $149

UNITRON PHASE CONTRAST — Models MPE, MPEA

MPE: Indispensable for the study of living cells and other highly transparent material. Continuous transition from phase to bright-field microscopy by adjusting condenser height. Choice of 4 contrasts. Mechanical stage. Three phase objectives: P10X, P40X, P100X. Eyepieces: 5X, 10X, P15X.

MPEA: a simplified version of MPE, 20 – 600X.

MPE $265
MPEA $99



UNITRON PHOTOMICROGRAPHY SET — Model ACA

Duplicates the performance of costly apparatus. Mounting brackets adjust to accommodate your present camera (35 mm., No. 120, No. 127, etc.). Viewing telescope permits all adjustments to be made while camera is in place and allows continuous observation of the specimen, even during time exposures.

ACA $39.95

UNITRON STEREOSCOPIC — Models MSH, MSL

MSH: for inspection, dissecting and other applications requiring a wide-field, 3-D view with great depth of focus. Inclined binocular head with distance and diopter adjustments. Revolving nosepiece. Choice of 3 objectives among 1X, 2X, 3X, 6X. Eyepieces: 8X, 12X, 15X. Models with both high and low stands.

MSL: single-magnification stereo with vertical binoculars.

MSH $267 up
MSL $110

FREE 10 DAY TRIAL
on any UNITRON MICROSCOPE . . .
Let the instrument prove its value to you in your own laboratory, before you decide to purchase.

These well known users are among the hundreds that have ordered — and re-ordered — UNITRON Microscopes. There must be a reason!

Harvard University
General Motors Corp.
U. S. Dep't of Agriculture
Princeton University
IBM Corp.
U. S. Army
U. S. Navy
Columbia University
Nat'l Bureau of Standards
Parke, Davis & Co.
E. I. du Pont
Union Carbide and Carbon
General Electric Co.
Goodyear Atomic Corp.
M.I.T.
Yale University
University of Chicago
Olin Mathieson Chemical
Procter and Gamble
Pittsburgh Plate Glass
Westinghouse Electric
Dow Chemical Co.
Brown University
Arthur D. Little Co.

THIS COMPLETE CATALOG ON UNITRON MICROSCOPES IS YOURS FOR THE ASKING

This colorful catalog gives complete specifications on the many UNITRON models available. Send for your free copy now.

UNITRON INSTRUMENT DIVISION OF UNITED SCIENTIFIC CO.
204-206 MILK STREET • BOSTON 9, MASSACHUSETTS

Please send me your complete catalog on UNITRON Microscopes.

Name _____
Title and Company _____
Address _____
City _____ State _____

FOR FURTHER INFORMATION CIRCLE 839 ON READER SERVICE CARD

type 874

. . . the Best Buy
in Coaxial Connectors

Quick Connect and Disconnect...
They plug smoothly into each other.
No twisting or threading is required.
Ideal for rapid changes in laboratory setups.

Positive Connection...
Strong friction grip provided by multiple spring fingers for uniform 50-ohm coaxial section.

Identical Mates...
No male or female connectors.
Eliminates searches for mating plugs.

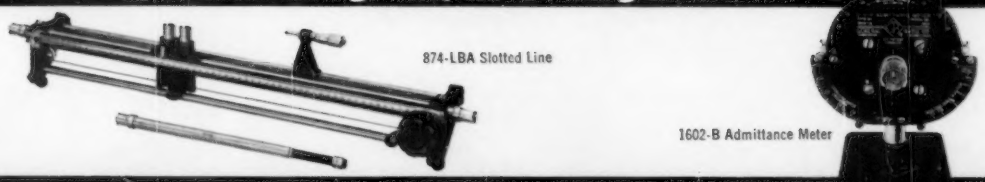
Low VSWR...
Less than 1.05 up to 4000 Mc.

a Wide Variety of Adaptors...

. . . for both male and female versions of N, C, BNC, HN, LC, and UHF connectors.

Many Accessories...

and Well-Integrated Measuring Instruments...



...and All at Low Cost

Basic connector costs only $1.25

GENERAL RADIO Company

275 Massachusetts Avenue, Cambridge 39, Mass., U.S.A.

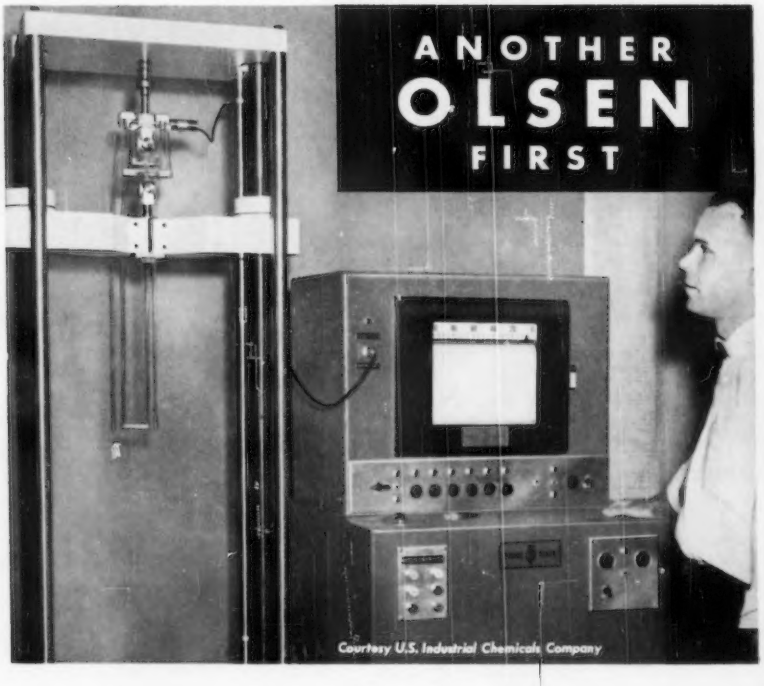
Broad Avenue at Linden, Ridgefield, N. J. **NEW YORK AREA**
1000 N. Seward St. **LOS ANGELES 38**
8055 13th St. Silver Spring, Md. **WASHINGTON, D. C.**
1150 York Road, Abington, Pa. **PHILADELPHIA**
1182 Los Altos Ave., Los Altos, Calif. **SAN FRANCISCO**
6605 W. North Ave., Oak Park, Ill. **CHICAGO**
In **CANADA:** 99 Floral Parkway, **TORONTO 15**

Write for the G-R **VHF-UHF Bulletin.**

All G-R Products are now covered by a

2-Year Warranty

FOR FURTHER INFORMATION CIRCLE 840 ON READER SERVICE CARD



Perfect STRESS-STRAIN *Curves*

EVEN WITH LOW TENSILE MATERIALS

Reliable stress-strain curves can now be plotted for all materials, including non-rigid plastics, films, metallic foils, fibres, rubber, fine wire, etc. with a Tinius Olsen XY Elec℧matic Universal Testing Machine.

Strain is recorded in terms of actual deformation in inches per inch between gauge points on the specimen itself using extensometers. These instruments are so counterbalanced that their weight does not impair specimens under test in any manner. Most important, the inaccuracies of "calculated" strain based on crosshead motion are eliminated. Fundamental engineering data can be obtained from Olsen XY Elec℧matic curves with full assurance of accuracy and reproducibility.

Other features of the Tinius Olsen XY Elec℧matic include:

- Eight standard testing ranges of up to 1/200 capacity are instantly available, while range capacities as low as 50 grams are obtained with auxiliary load cells.
- Electronically controlled testing speeds are positive under load or no load.
- Hot and cold temperature cabinets and high temperature furnaces available for use in the testing machine.

For complete testing flexibility, and accuracy under all testing conditions, get the facts about the Tinius Olsen XY Elec℧matic UTM.

Write for information today.

Trademark
Reg. U.S. Pat. Off.

TINIUS OLSEN
TESTING MACHINE COMPANY
2020 EASTON ROAD • WILLOW GROVE, PA.
Testing and Balancing Machines

REPRESENTATIVES

PACIFIC SCIENTIFIC CO.
Los Angeles and San Francisco, Calif.; Seattle, Wash.; Portland, Ore.

MINE & SMELTER SUPPLY CO.
Denver, Colo.; Salt Lake City, Utah; El Paso, Texas; Tucson, Ariz.

KINETROL COMPANY
Dallas, Texas

THE EADS COMPANY
Houston, Texas

LABQUIP CORPORATION
Chicago, Ill.

THE GIL OUTTERSON CO.
Cincinnati and Cleveland, Ohio

E. E. BOON
Pittsburgh, Pa.

H. G. GRAFF CO.
Boston, Mass.

F. R. JODON INC.
Washington, D. C.

THE ELLISON COMPANY
Atlanta, Ga.

Exclusive Canadian Representative
UPTON BRADEEN & JAMES LTD.
Toronto; Montreal; Hamilton; Windsor; Ottawa; Winnipeg; Edmonton; Vancouver

Soils Testing Only
SOIL TESTING SERVICES OF CALIF. INC.
San Francisco, Calif.

KAROL-WARNER CO.
Highland Park, N. J.

FOR FURTHER INFORMATION CIRCLE 841 ON READER SERVICE CARD